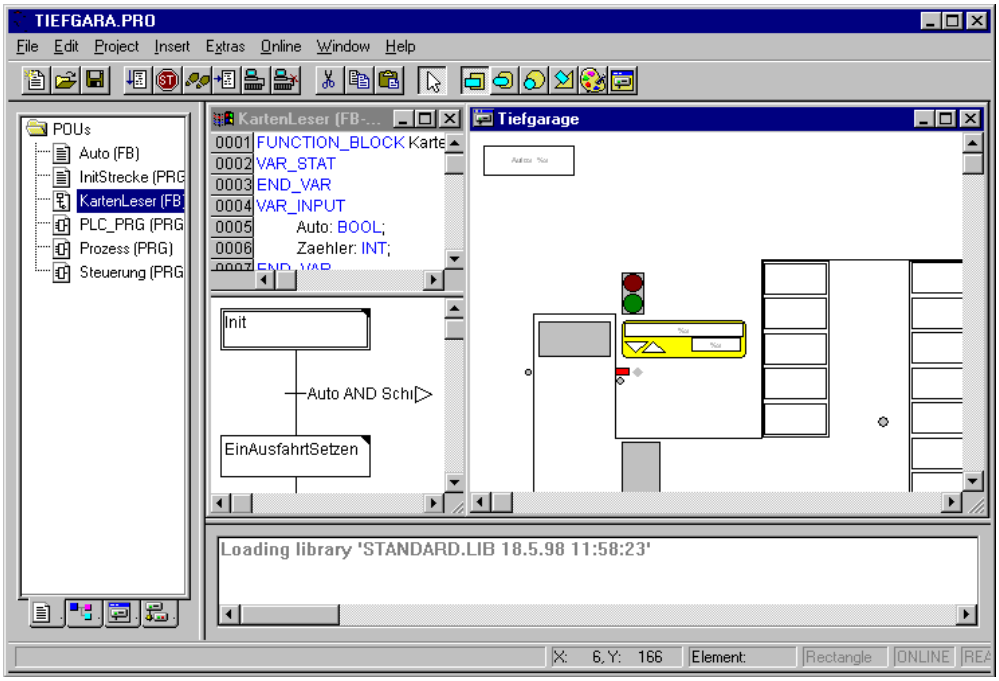
WAGO I/O SYSTEM 759

Programming Tool IEC 61131-3

WAGO-I/O-I/O-PRO 32



Manual Part 1

Technical description

Chapter 1 - 14

759-122/000-002
Version 2.0.0

WAGO® INNOVATIVE CONNECTIONS

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Every conceivable measure has been taken to ensure the correctness and completeness of this documentation. However, as errors can never be fully excluded we would appreciate any information or ideas at any time.

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The chapters 15 ff. and Appendix are placed in part 2.

1 Important Comments

To ensure fast installation and start-up of the units described in this manual, we strongly recommend that the following information and explanations are carefully read and abided by.

1.1 Legal Principles

1.1.1 Copyright

This manual is copyrighted, together with all figures and illustrations contained therein. Any use of this manual which infringes the copyright provisions stipulated herein, is not permitted. Reproduction, translation and electronic and photo-technical archiving and amendments require the written consent of WAGO Kontakttechnik GmbH. Non-observance will entail the right of claims for damages.

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1.1.2 Personnel Qualification

The use of the product detailed in this manual is exclusively geared to specialists having qualifications in PLC programming, electrical specialists or persons instructed by electrical specialists who are also familiar with the valid standards. WAGO Kontakttechnik GmbH declines all liability resulting from improper action and damage to WAGO products and third party products due to non-observance of the information contained in this manual.

1.1.3 Intended Use

For each individual application, the components supplied are to work with a dedicated hardware and software configuration. Modifications are only permitted within the framework of the possibilities documented in the manuals. All other changes to the hardware and/or software and the non-conforming use of the components entail the exclusion of liability on part of WAGO Kontakttechnik GmbH.

Please direct any requirements pertaining to a modified and/or new hardware or software configuration directly to WAGO Kontakttechnik GmbH.

1.2 Symbols

Danger
Always abide by this information to protect persons from injury.

Warning
Always abide by this information to prevent damage to the device.

Attention
Marginal conditions must always be observed to ensure smooth operation.

ESD (Electrostatic Discharge)
Warning of damage to the components by electrostatic discharge. Observe the precautionary measure for handling components at risk.

Note
Routines or advice for efficient use of the device and software optimization.

More information
References on additional literature, manuals, data sheets and INTERNET pages

1.3 Font Conventions

Italic	Names of path and files are marked italic i.e.: *C:\programs\WAGO-IO-CHECK*
Italic	Menu items are marked as bold italic i.e.: ***Save***
\	A backslash between two names marks a sequence of menu items i.e.: ***File\New***
END	Press buttons are marked as bold with small capitals i.e.: **ENTER**
< >	Keys are marked bold within angle brackets i.e.: **<F5>**
`Courier`	Program code is printed with the font `Courier`. i.e.: `END_VAR`

1.4 Number Notation

Number Code	Example	Note
Decimal	100	normal notation
Hexadecimal	0x64	C notation
Binary	'100' '0110.0100'	Within ', Nibble separated with dots

1.5 Scope

This manual describes the following components:

Item-No.	Components
759-332/000-001	Programming Tool IEC 61131-3 **WAGO-I/O-PRO 32** V2.2

1.6 Abbreviations

AO	Analog Output Module
AI	Analog Input Module
DI	Digital Input
DO	Digital Output
I/O	input/output

1.7 Scope of Delivery

WAGO-I/O-PRO 32 comprises of the following components:

1 pc user manual **WAGO-I/O-PRO 32**, English	Order No.: 759-122/000-002
1 pc communication cable	Order No.: 750-920
1 pc installation CD-ROM	
1 pc Software Licence Agreement	
= Programming Tool IEC 61131-3	**Order No.: 759-332/000-001**

1.8 System Configuration

Minimum system requirements:

PC	Pentium processor
Operating system	Microsoft Windows 95 or better
Main memory	Windows 95: 16 MB Windows NT 4.0: 32 MB
	For the graphic representation of the node, we recommend to have your PC equipped with a higher capacity main memory.
Fixed disk storage	recommended: 10 MB
Monitor	VGA or better
Resolution	Min. 800 x 600, Max. 1024 x 768 with a display of 256 colours or better
Mouse	required
Disk drive	CD-ROM
Others	free serial interface, COM 1 ... 4

1.9 Installation

WAGO-I/O-PRO 32 comes on installation CD-ROM and contains all program files required for the application. Installation of the programs does not differ from the installation method used for most other Windows 95 or Windows NT applications.

How to install **WAGO-I/O-PRO 32**:

If Windows 98 or Windows NT are not active, start your operating system now.

Insert the installation CD-ROM in your CD-ROM drive.

If Autorun is active on your system, **WAGO-I/O-PRO 32** is installed automatically and you can skip the next paragraph.

If the setup-program does not start automatically, open the Windows Explorer and select the desired CD-ROM drive. Start the installation with a double click on the „*Setup.exe*“ file
or select in the Windows ***Start Menu*** the entry ***Run*** and enter the drive and the file name „*Setup.exe*“ in the entry field, e. g. „A:*Setup.exe*“. Start the installation by clicking the **OK** button.

Carry out the screen-dialog instructions in order to conduct the installation.

1.10 Uninstall

How to uninstall **WAGO-I/O-PRO 32**:

Click on the **START** symbol in the Windows task bar in order to open the ***Start*** menu.

Select the ***Programs*** option in the ***Start*** menu to be able to open the ***Programs*** folder.

Select ***Wago**** to open the ***Wago**** folder.

Select ***WAGO-IO-PRO 32**** to be able to open the ***WAGO-IO-PRO 32**** folder.

Click on the ***WAGO-IO-PRO 32 uninstall*** link

Follow the instructions on the screen to uninstall **WAGO-I/O-PRO 32** from your system.

* or the name you have selected

You can also uninstall **WAGO-I/O-PRO 32** using the Windows uninstall program.

From the Windows ***Start*** menu, select ***Program***, and then ***Control Panel***.

Double-click on ***Add/Remove Programs***.

Select **WAGO-I/O-PRO 32**

Click on **ADD/REMOVE**.

Follow the instructions on the screen to uninstall **WAGO-I/OPRO 32** from your system.

1.11 Start

WAGO-I/O-PRO 32 can be started in one of the following manners:

Start Menu

Click on the **START** symbol in the Windows task bar in order to open the ***Start*** menu.

Select the ***Programs*** option in the ***Start*** menu to open the ***Programs*** folder.

Select ***Wago**** to open the ***Wago**** folder.

Select ***WAGO-IO-PRO 32**** in order to open the ***WAGO-IO-PRO 32**** folder.

Click on the ***WAGO-IO-PRO 32*** link.

* or the name you have selected

„Desktop“ - Windows Explorer

WAGO-I/O-PRO 32 can be started with the „Desktop“ symbol or the Windows Explorer by a double click on the *WAGO-IO-PRO 32.exe* file in the „WAGO-IO-PRO 32“ folder or by labelling the file and pressing the **<Enter*>** key. The *WAGO-IO-PRO 32.exe* file is on the drive and in the folder which you have entered at the time of installation. If you have not changed the default settings when installing, the *WAGO-IO-PRO 32.exe* file is in the folder,

C:\Programme\Wago\WAGO-IO-PRO 32

* or CR, ↵

1.12 Important Informations

When working with **WAGO-I/O-*PRO* 32** please observe the following information:

Warning!
If during a status change from "Run" to "Stop" outputs are still active (e.g. for motor contactors or valves), they will remain active! Software cut-outs (e.g. by initiators) are then ineffective as the programme is not processed any more! The change of operation mode takes place internally at the end of a programme cycle!

Note:
In the event of an endless loop the outputs deactivate via the Watchdog of the output terminal blocks. In this case, a communication with the controller is impossible. (To restore communication, switch the supply voltage of the controller off and on again. You can re-establish the communication by pressing the function selector. This selector must then be either in the top or central position.)
The Programmer has to ensure that no endless loop can occur!

2 WAGO-I/O-PRO 32 V2.2 Overview

2.1 What is WAGO-I/O-PRO 32

WAGO-I/O-*PRO* 32 is a complete development environment for your PLC. (**WAGO-I/O-*PRO* 32** stands for Controlled Developement System).

WAGO-I/O-*PRO* 32 puts a simple approach to the powerful IEC language at the disposal of the PLC programmer. Use of the editors and debugging functions is based upon the proven development program environments of advanced programming languages (such as Visual C++).

2.2 Overview of WAGO-I/O-PRO 32 Functions

2.2.1 How is a project structured?

A project is put into a file named after the project. The first POU (Program Organization Unit) created in a new project will automatically be named PLC_PRG. The process begins here (in compliance with the main function in a C program), and other POUs can be accessed from the same point (programs, function block s and functions).

Once you have defined a Task Configuration, it is no longer necessary to create a program named PLC_PRG. You will find more about this in the Task Configuration chapter.

There are different kinds of objects in a project: POUs, data types, display elements (visualizations) and resources.

The Object Organizer contains a list of all the objects in your project.

2.2.2 How do I set up my project?

First you should configure your PLC in order to check the accuracy of the addresses used in the project.

Then you can create the POUs needed to solve your problem.

Now you can program the POUs you need in the desired languages.

Once the programming is complete, you can compile the project and remove errors should there be any.

2.2.3 How can I test my project?

Once all errors have been removed, activate the simulation, log in to the simulated PLC and "load" your project in the PLC. Now you are in Online mode.

Now open the window with your PLC Configuration and test your project for correct sequence. To do this, enter input variables manually and observe whether outputs are as expected. You can also observe the value sequence of the local variables in the POUs. In the Watch and Receipt Manager you can configure data records whose values you wish to examine.

2.2.4 Debugging

In case of a programming error you can set breakpoints. If the process stops at such a breakpoint, you can examine the values of all project variables at this point in time. By working through sequentially (single step) you can check the logical correctness of your program.

2.2.5 Additional Online Functions

Further debugging functions:

You can **set** program variables and inputs and outputs **at certain values**.

You can use the **flow control** to check which program lines have been run.

A Log records operations, user actions and internal processes during an online session in a chronological order.

The Sampling Trace allows you to trace and display the actual course of variables over an extended period of time.

Optional a PLC Browser is available to request certain information from the PLC.

Once the project has been set up and tested, it can be **loaded down to the hardware** and tested as well. The same online functions as you used with the simulation will be available.

2.2.6 Additional WAGO-I/O-PRO 32 Features

The entire project can be documented or exported to a text file at any time.

2.2.7 Summary

WAGO-I/O-*PRO* 32 is a complete development tool used to program your PLC which will save you a measurable amount of time setting up your applications.

2.3 Project Components

2.3.1 Project

A project contains all of the objects in a PLC program. A project is saved in a file named after the project. The following objects are included in a project:

POUs (Program Organization Units), data types, visualizations, resources, and libraries.

2.3.2 POU (Program Organization Unit)

Functions, function blocks, and programs are POUs which can be supplemented by actions.

Each POU consists of a declaration part and a body. The body is written in one of the IEC programming languages which include IL, ST, SFC, FBD, LD or CFC.

WAGO-I/O-*PRO* 32 supports all IEC standard POUs. If you want to use these POUs in your project, you must include the library standard.lib in your project.

POUs can call up other POUs. However, recursions are not allowed.

2.3.3 Function

A function is a POU, which yields exactly one data element (which can consist of several elements, such as fields or structures) when it is processed, and whose call in textual languages can occur as an operator in expressions.

When declaring a function do not forget that the function must receive a type. This means, after the function name, you must enter a colon followed by a type.

A correct function declaration can look like this example:

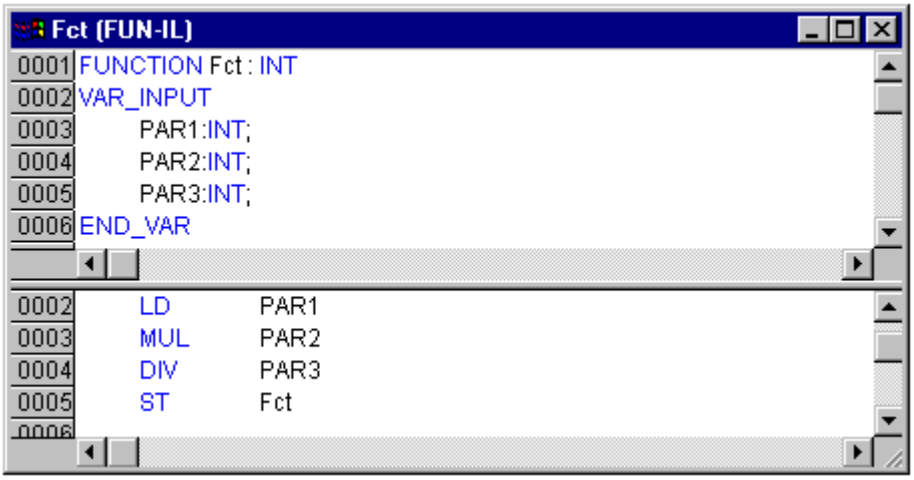
```
FUNCTION Fct:    INT
```

In addition, a result must be assigned to the function. That means that function name is used as an output variable.

A function declaration begins with the keyword FUNCTION.

Example in IL of a function that takes three input variables and returns the product of the first two divided by the third:

X Example of a function in IL



The call of a function in ST can appear as an operand in expressions.

Functions do not have any internal conditions. That means that calling up a function with the same argument (input parameters) always produces the same value (output).

In SFC a function call can only take place within a step or a transition.

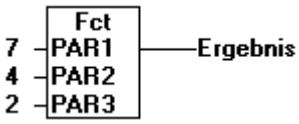
in IL:

```
LD    7

Fct   2,4

ST    Result
```

in ST:

```
Result := Fct(7, 2, 4);
```

in FBD:



If you define a function in your project with the name **CheckBounds**, you can use it to check range overflows in your project! The name of the function is defined and may have only this identifier. For further description please see chapter **Operators** of the Online Help chapters, DIV.

If you define functions in your project with the names **CheckDivByte**, **CheckDivWord**, **CheckDivDWord** and **CheckDivReal**, you can use them to check the value of the divisor if you use the operator DIV, for example to avoid a division by 0.

If you define functions with the names **CheckRangeSigned** and **CheckRangeUnsigned**, then range exceeding of variables declared with subrange types (see chapter Data types of the online help chapters,) can be intercepted.

All these check function names are reserved for the described usage. For further description please see chapter **Datatypes** of the Online Help chapters, Array.

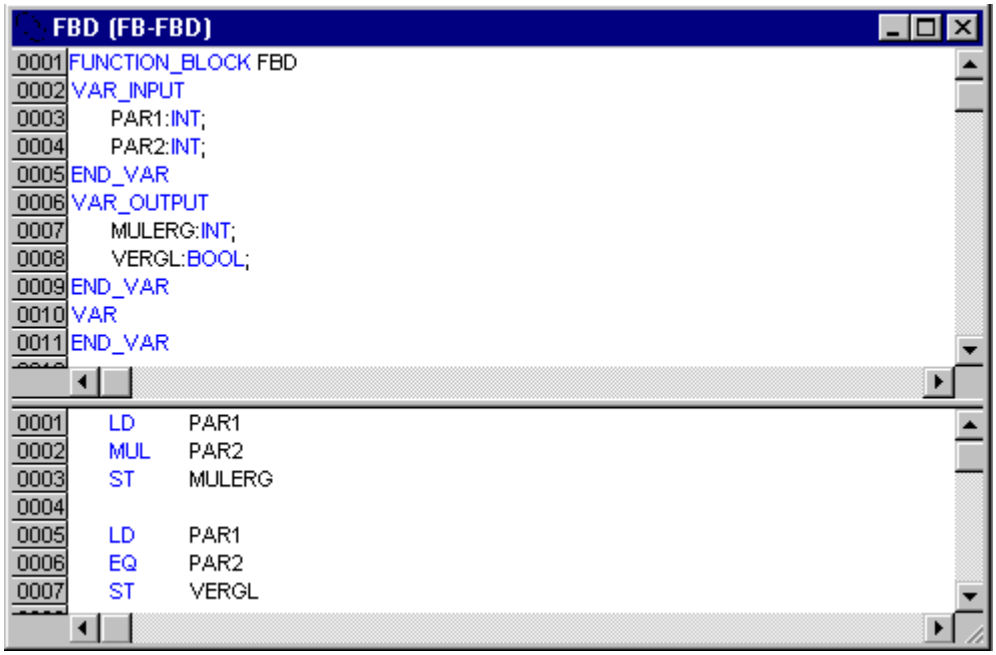
2.3.4 Function Block

A function block is a POU which provides one or more values during the procedure. As opposed to a function, a function block provides no return value.

A function block declaration begins with the keyword FUNCTION_BLOCK.

Reproductions or instances (copies) of a function block can be created.

X Example of a function block in IL



Example in IL of a function block with two input variables and two output variables. One output is the product of the two inputs, the other a comparison for equality:

2.3.5 Function Block Instances

Reproductions or *instances* (copies) of a function block can be created.

Each instance possesses its own identifier (the instance name), and a data structure which contains its inputs, outputs, and internal variables. Instances

are declared locally or globally as variables, whereas the name of the function block is indicated as the type of an identifier.

Example of an instance with the name INSTANCE of the FUB function block:

```
INSTANCE: FUB;
```

Function blocks are always called through the instances described above.

Only the input and output parameters can be accessed from outside of an function block instance, not its internal variables.

X Example for accessing an input variable

The function block FB has an input variable in1 of the type INT.

```
PROGRAM prog

VAR

      inst1:fb;

END_VAR

LD    17

ST    inst1.in1

CAL   inst1

END_PROGRAM
```

The declaration parts of function blocks and programs can contain instance declarations. Instance declarations are not permitted in functions.

Access to a function block instance is limited to the POU in which it was declared unless it was declared globally.

The instance name of a function block instance can be used as the input for a function or a function block.

Note:
All values are retained after processing a function block until the next it is processed. Therefore, function block calls with the same arguments do not always return the same output values!

Note:
If there at least one of the function block variables is a retain variable, the total instance is stored in the retain area.

2.3.6 Calling a function block

The input and output variables of a function block can be accessed from another POU by setting up an instance of the function block and specifying the desired variable using the following syntax:

<Instance name>.<Variable name>

If you would like to set the input parameters when you open the function block, you can do this in the text languages IL and ST by assigning values to the parameters after the instance name of the function block in parentheses (this assignment takes place using ":=" just as with the initialization of variables at the declaration position).

Please regard, that the InOutVariables (VAR_IN_OUT) of a function block are handed over as pointers. For this reason in a call of a function block no constants can be assigned to VAR_IN_OUTs and there is no read or write access from outside to them.

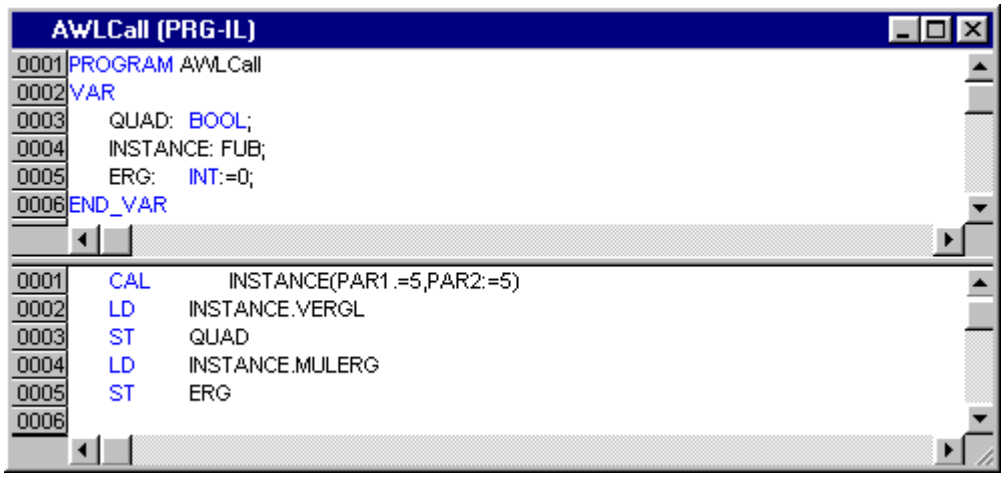
```
VAR
      inst:fubo;
      var:int;
END_VAR
var1:=2;
inst(instout1:=var1^);
```

not allowed in this case: inst(instout1:=2); or inst.inout1:=2;

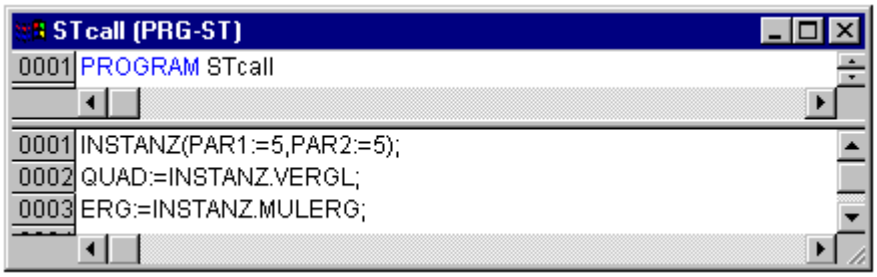
Examples for calling function block FUB:

The multiplication result is saved in the variable ERG, and the result of the comparison is saved in QUAD. An instance of FUB with the name INSTANCE is declared.

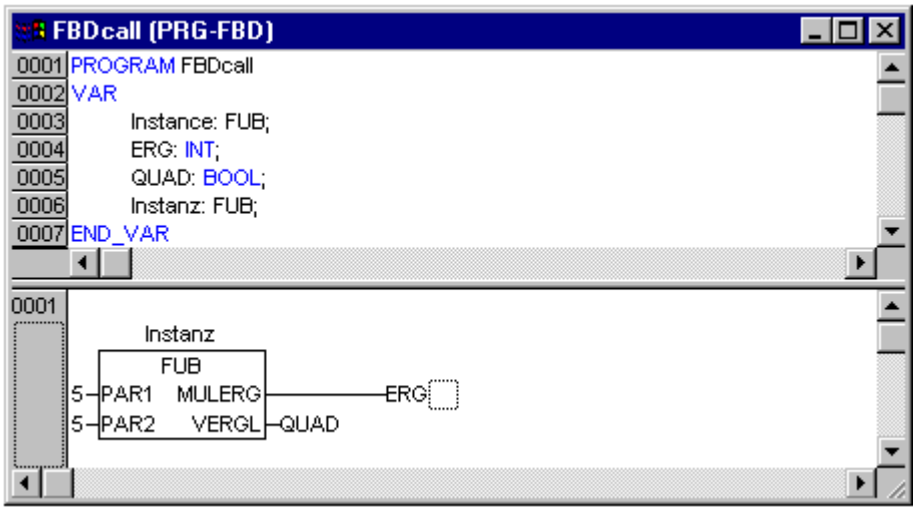
X This is how the instance of a function block is called in IL



X This is how the instance of a function block is called in ST (the declaration part the same as with IL)



X This is how the instance of a function block is called in FBD (the declaration part the same as with IL)

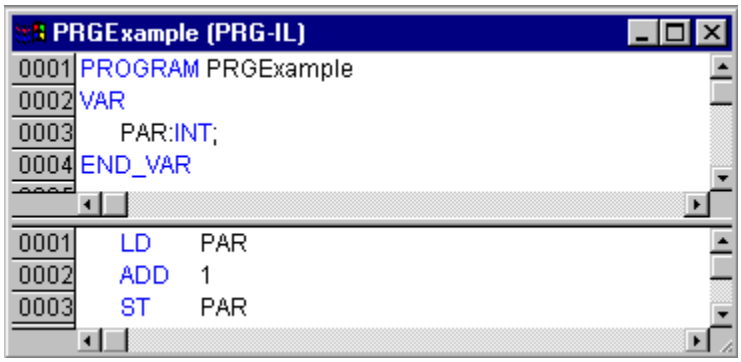


In SFC function block calls can only take place in steps.

2.3.7 Program

A program is a POU which returns several values during operation. Programs are recognized globally throughout the project. All values are retained from the last time the program was run until the next.

X Example of a program



Programs can be called. A program call in a function is not allowed. There are also no instances of programs.

If a POU calls a program, and if thereby values of the program are changed, then these changes are retained the next time the program is called, even if the program has been called from within another POU.

This is different from calling a function block. There only the values in the given instance of a function block are changed.

These changes therefore play a role only when the same instance is called.

A program declaration begins with the keyword PROGRAM and ends with END_PROGRAM.

Examples for program calls:

In IL:

```
CAL   PRGExample

LD    PRGexample.PAR

ST    ERG
```

In ST:

```
PRGExample;

Erg := PRGexample.PAR;
```

In FBD :

Example for a possible call sequence for PLC_PRG:

```
LD    0
```

```
ST    PRGexample.PAR   (*Default setting for PAR is 0*)

CAL   IL call     (*ERG in IL call results in 1*)

CAL   ST call     (*ERG in ST call results in 2*)

CAL   FBD call    (*ERG in FBD call results in 3*)
```

If the variable PAR from the program PRGexample is initialized by a main program with 0, and then one after the other programs are called with above named program calls, then the ERG result in the programs will have the values 1, 2, and 3. If one exchanges the sequence of the calls, then the values of the given result parameters also change in a corresponding fashion.

2.3.8 PLC_PRG

The PLC_PRG is a special predefined POU. Each project must contain this special program. This POU is called exactly once per control cycle.

The first time the **'Project' 'Object Add'** command is used after a new project has been created, the default entry in the POU dialog box will be a POU named PLC_PRG of the program type. You should not change this default setting!

If tasks have been defined, then the project may not contain any PLC_PRG, since in this case the procedure sequence depends upon the task assignment.

Attention:
Do not delete or rename the POU PLC_PRG (assuming you are not using a Task Configuration)! PLC_PRG is generally the main program in a single task program.

2.3.9 Action

Actions can be defined to function blocks and programmes. The action represents a further implementation which can be entirely created in another language as the "normal" implementation. Each action is given a name.

An action works with the data from the function block or programme which it belongs to. The action uses the same input/output variables and local variables as the "normal" implementation uses.

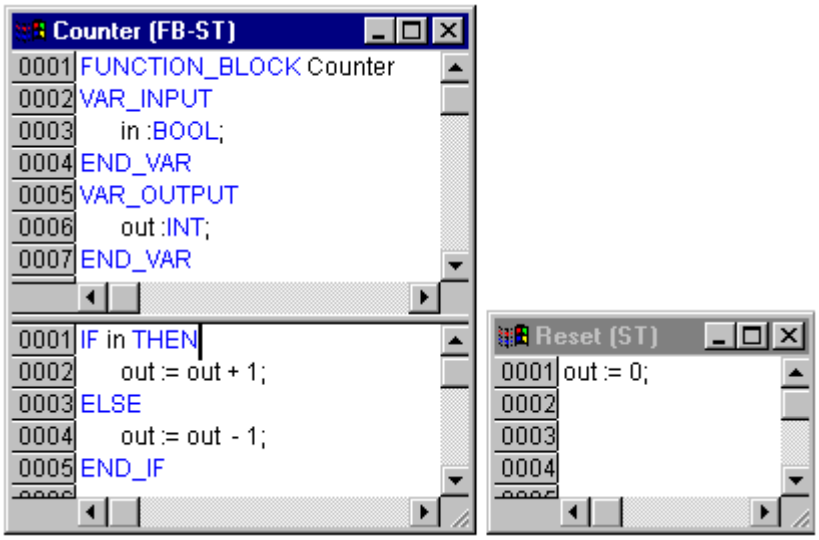
X Example for an action of a function block

In the example given, calling up the function block Counter increases or decreases the output variable "out", depending on the value of the input variable "in". Calling up the action Reset of the function block sets the output variable to zero. The same variable "out" is written in both cases.

An action is called up with <Program_name>.<Action_name> or <Instance_name>.<Action_name>. If it is required to call up the action within

its own block, one just uses the name of the action in the text editors and in the graphic form the function block call up without instance information.

X Example for calls of the above mentioned action



Note:
Actions play an important role in blocks in sequential function charts, see Sequential Function Chart - SFC.

The IEC standard does not recognise actions other than actions of the sequential function chart.

Declaration for all examples:

```
PROGRAM PLC_PRG

VAR

      Inst : Counter;

END_VAR
```

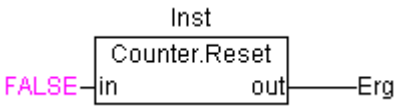
Call in IL:

```
CAL   Inst.Reset(In := FALSE)

LD    Inst.out

ST    ERG
```

Call in ST:

```
Inst.Reset(In := FALSE);

Erg := Inst.out;
```

Call in FBD:



2.3.10 Resources

You need the resources for configuring and organizing your project and for tracing variable values:

2.3.11 Libraries

You can include in your project a series of libraries whose POUs, data types, and global variables you can use just like user-defined variables. The libraries standard.lib and util.lib are standard parts of the program and are always at your disposal.

See 'Library Manager'.

2.3.12 Data types

Along with the standard data types the user can define his own data types. Structures, enumeration types and references can be created.

See chapter 'Data Types' of the Online Help chapters.

2.3.13 Visualization

WAGO-I/O-*PRO* 32 provides visualizations so that you can display your project variables. You can plot geometric elements off-line with the help of the visualization. In Online mode, these can then change their form/color/text output in response to specified variable values.

See 'Visualization'.

2.4 Languages

2.4.1 Instruction List (IL)

An instruction list (IL) consists of a series of instructions. Each instruction begins in a new line and contains an operator and, depending on the type of operation, one or more operands separated by commas.

In front of an instruction there can be an identification *mark* (label) followed by a colon (:).

A comment must be the last element in a line. Empty lines can be inserted between instructions.

Example:

```
LD    17
```

```
ST    lint  (* comment *)

GE    5

JMPC  next

LD    idword

EQ    istruct.sdword

STN   test

next:
```

2.4.1.1 Modifiers and operators in IL

In the IL language the following operators and modifiers can be used.

Modifiers:

C	with JMP, CAL, RET:	The instruction is only then executed if the result of the preceding expression is TRUE.
N	with JMPC, CALC, RETC:	The instruction is only then executed if the result of the preceding expression is FALSE.
N	otherwise:	Negation of the operand (not of the accumulator)

Below you find a table of all operators in IL with their possible modifiers and the relevant meaning:

Operator	Modifiers	Meaning
LD	N	Make current result equal to the operand
ST	N	Save current result at the position of the operand
S		Then put the Boolean operand exactly at TRUE if the current result is TRUE
R		Then put the Boolean operand exactly at FALSE if the current result is TRUE
AND	N,(	Bitwise AND
OR	N,(	Bitwise OR
XOR	N,(	Bitwise exclusive OR

Operator	Modifiers	Meaning
ADD	(	Addition
SUB	(	Subtraction
MUL	(	Multiplication
DIV	(	Division
GT	(	>
GE	(	>=
EQ	(	=
NE	(	<>
LE	(	<=
LT	(	<
JMP	CN	Jump to the label
CAL	CN	Call programor function block or
RET	CN	Leave POU and return to caller.
)		Evaluate deferred operation

You find a list of all IEC operators in the appendix.

Example of an IL program while using some modifiers:

```
LD    TRUE  (*load TRUE in the accumulator*)

ANDN  BOOL1 (*execute AND with the negated value of the
      BOOL1 variable*)

JMPC  mark  (*if the result was TRUE, then jump to the
      label "mark"*)



LDN   BOOL2 (*save the negated value of *)

ST    ERG   (*BOOL2 in ERG*)

label:

LD    BOOL2 (*save the value of *)
```

```
ST    ERG   *BOOL2 in ERG*)
```

It is also possible in IL to put parentheses after an operation. The value of the parenthesis is then considered as an operand.

For example:

```
LD    2

MUL   2

ADD   3

ST    ERG
```

Here is the value of Erg 7. However, if one puts parentheses:

```
LD    2

MUL   (2

ADD   3

)

ST    ERG
```

Here the resulting value for Erg is 10, the operation MUL is only then evaluated if you come to ")"; as operand for MUL 5 is then calculated.

2.4.2 Structured Text (ST)

The Structured Text consists of a series of instructions which, as determined in high level languages, ("IF..THEN..ELSE") or in loops (WHILE..DO) can be executed.

Example:

```
IF value < 7 THEN

      WHILE value < 8 DO

      value:=value+1;

      END_WHILE;

END_IF;
```

2.4.2.1 Expressions

An *expression* is a construction which returns a value after its evaluation.

Expressions are composed of operators and operands. An operand can be a constant, a variable, a function call, or another expression.

2.4.2.2 Valuation of expressions

The evaluation of expression takes place by means of processing the operators according to certain *binding rules*. The operator with the strongest binding is processed first, then the operator with the next strongest binding, etc., until all operators have been processed.

Operators with equal binding strength are processed from left to right.

Below you find a table of the ST operators in the order of their binding strength:

Operation	Symbol	Binding strength
Put in parentheses	(expression)	Strongest binding
Function call	Function name (parameter list)	
Exponentiation	EXPT	
Negate Building of complements	- NOT	
Multiply Divide Modulo	* / MOD	
Add Subtract	+ -	
Compare	<,>,<=,>=	
Equal to Not equal to	= <>	
Boolean AND	AND	
Boolean XOR	XOR	
Boolean OR	OR	Weakest binding

There are the following instructions in ST, arranged in a table together with example:

Instruction type	Example
Assignment	A:=B; CV := CV + 1; C:=SIN(X);

Instruction type	Example
Calling a function block and use of the FB output	CMD_TMR(IN := %IX5, PT := 300); A:=CMD_TMR.Q
RETURN	RETURN;

IF	D:=B*B;
	
	IF D<0.0 THEN
	
	C:=A;
	
	ELSIF D=0.0 THEN
	
	C:=B;
	
	ELSE
	
	C:=D;
	END_IF;

CASE	CASE INT1 OF 1:BOOL1 := TRUE; 2:BOOL2 := TRUE; ELSE BOOL1 := FALSE; BOOL2 := FALSE; END_CASE;

FOR	J:=101;
	
	FOR I:=1 TO 100 BY 2 DO
	
	IF ARR[I] = 70 THEN
	
	J:=I;
	EXIT;
	
	END_IF;
	
	END_FOR;

Instruction type	Example
WHILE	J:=1; WHILE J<= 100 AND ARR[J] <> 70 DO J:=J+2; END_WHILE;
REPEAT	J:=-1; REPEAT J:=J+2; UNTIL J= 101 OR ARR[J] = 70 END_REPEAT;
EXIT	EXIT;
Empty instruction	;

2.4.2.3 Assignment operator

On the left side of an assignment there is an operand (variable, address) to which is assigned the value of the expression on the right side with the assignment operator :=

Example:

```
Var1 := Var2 * 10;
```

After completion of this line Var1 has the tenfold value of Var2.

2.4.2.4 Calling function blocks in ST

A function block is called in ST by writing the name of the instance of the function block and then assigning the values of the parameters in parentheses. In the following example a timer is called with assignments for the parameters IN and PT. Then the result variable Q is assigned to the variable A.

The result variable, as in IL, is addressed with the name of the function block, a following point, and the name of the variable:

```
CMD_TMR(IN := %IX5, PT := 300);

A:=CMD_TMR.Q
```

2.4.2.5 RETURN instruction

The RETURN instruction can be used to leave a POU, for example depending on a condition

2.4.2.6 IF instruction

With the IF instruction you can check a condition and, depending upon this condition, execute instructions.

Syntax:

```
IF <Boolean_expression1> THEN
      <IF_instructions>
{ELSIF <Boolean_expression2> THEN
      <ELSIF_instructions1>




ELSIF <Boolean_expression n> THEN
      <ELSIF_instructions n-1>
ELSE
      <ELSE_instructions>}
END_IF;
```

The part in braces {} is optional.

If the <Boolean_expression1> returns TRUE, then only the <IF_Instructions> are executed and none of the other instructions.

Otherwise the Boolean expressions, beginning with <Boolean_expression2>, are evaluated one after the other until one of the expressions returns TRUE. Then only those instructions after this Boolean expression and before the next ELSE or ELSIF are evaluated.

If none of the Boolean expressions produce TRUE, then only the <ELSE_instructions> are evaluated.

Example:

```
IF    temp<17
THEN  heating_on := TRUE;
ELSE  heating_on := FALSE;
```

```
END_IF;
```

Here the heating is turned on when the temperature sinks below 17 degrees. Otherwise it remains off.

2.4.2.7 CASE instruction

With the CASE instructions one can combine several conditioned instructions with the same condition variable in one construct.

Syntax:

```
CASE <Var1> OF

<Value1>:  <Instruction 1>

<Value2>:  <Instruction 2>

<Value3, Value4, Value5>:  <Instruction 3>

<Value6 .. Value10>:  <Instruction 4>

      ...

<Value n>: <Instruction n>

ELSE  <ELSE instruction>

END_CASE;
```

A CASE instruction is processed according to the following model:

- If the variable in <Var1> has the value <Value i>, then the instruction <Instruction i> is executed.
- If <Var 1> has none of the indicated values, then the <ELSE Instruction> is executed.
- If the same instruction is to be executed for several values of the variables, then one can write these values one after the other separated by commas, and thus condition the common execution.
- If the same instruction is to be executed for a value range of a variable, one can write the initial value and the end value separated by two dots one after the other. So you can condition the common condition.

Example:

```
CASE INT1 OF

1, 5: BOOL1 := TRUE;

      BOOL3 := FALSE;

2:    BOOL2 := FALSE;

      BOOL3 := TRUE;
```

```
10..20: BOOL1 := TRUE;

      BOOL3:= TRUE;

ELSE

      BOOL1 := NOT BOOL1;

      BOOL2 := BOOL1 OR BOOL2;

END_CASE;
```

2.4.2.8 FOR loop

With the FOR loop one can program repeated processes.

Syntax:

```
INT_Var :INT;

FOR <INT_Var> := <INIT_VALUE> TO <END_VALUE> {BY <Step
      size>} DO

      <Instructions>

END_FOR;
```

The part in braces {} is optional.

The <Instructions> are executed as long as the counter <INT_Var> is not greater than the <END_VALUE>. This is checked before executing the <Instructions> so that the <instructions> are never executed if <INIT_VALUE> is greater than <END_VALUE>.

When <Instructions> are executed, <INT_Var> is always increased by <Step size>. The step size can have any integer value. If it is missing, then it is set to 1. The loop must also end since <INT_Var> only becomes greater.

Example:

```
FOR Counter:=1 TO 5 BY 1 DO

Var1:=Var1*2;

END_FOR;

Erg:=Var1;
```

Let us assume that the default setting for Var1 is the value 1. Then it will have the value 32 after the FOR loop.

Note:
<END_VALUE> must not be equal to the limit value of the counter <INT_VAR>. For example: If the variable Counter is of type SINT and if

<END_VALUE> is 127, you will get an endless loop.

2.4.2.9 WHILE loop

The WHILE loop can be used like the FOR loop with the difference that the break-off condition can be any Boolean expression. This means you indicate a condition which, when it is fulfilled, the loop will be executed.

Syntax:

```
WHILE <Boolean expression>

      <Instructions>

END_WHILE;
```

The <Instructions> are repeatedly executed as long as the <Boolean_expression> returns TRUE. If the <Boolean_expression> is already FALSE at the first evaluation, then the <Instructions> are never executed. If <Boolean_expression> never assumes the value FALSE, then the <Instructions> are repeated endlessly which causes a relative time delay.

Note:
The programmer must make sure that no endless loop is caused. He does this by changing the condition in the instruction part of the loop, for example, by counting up or down one counter.

Example:

```
WHILE counter<>0 DO

      Var1 := Var1*2;

      Counter := Counter-1;

END_WHILE
```

The WHILE and REPEAT loops are, in a certain sense, more powerful than the FOR loop since one doesn't need to know the number of cycles before executing the loop. In some cases one will, therefore, only be able to work with these two loop types. If, however, the number of the loop cycles is clear, then a FOR loop is preferable since it allows no endless loops.

2.4.2.10 REPEAT loop

The REPEAT loop is different from the WHILE loop because the break-off condition is checked only after the loop has been executed. This means that the loop will run through at least once, regardless of the wording of the break-off condition.

Syntax:

```
REPEAT

      <Instructions>

UNTIL <Boolean expression>

END_REPEAT;
```

The <Instructions> are carried out until the <Boolean expression> returns TRUE.

If <Boolean expression> is produced already at the first TRUE evaluation, then <Instructions> are executed only once. If <Boolean_expression> never assumes the value TRUE, then the <Instructions> are repeated endlessly which causes a relative time delay.

Note:
The programmer must make sure that no endless loop is caused. He does this by changing the condition in the instruction part of the loop, for example by counting up or down one counter.

Example:

```
REPEAT

      Var1 := Var1*2;

      Counter := Counter-1;

UNTIL

      Counter=0

END_REPEAT;
```

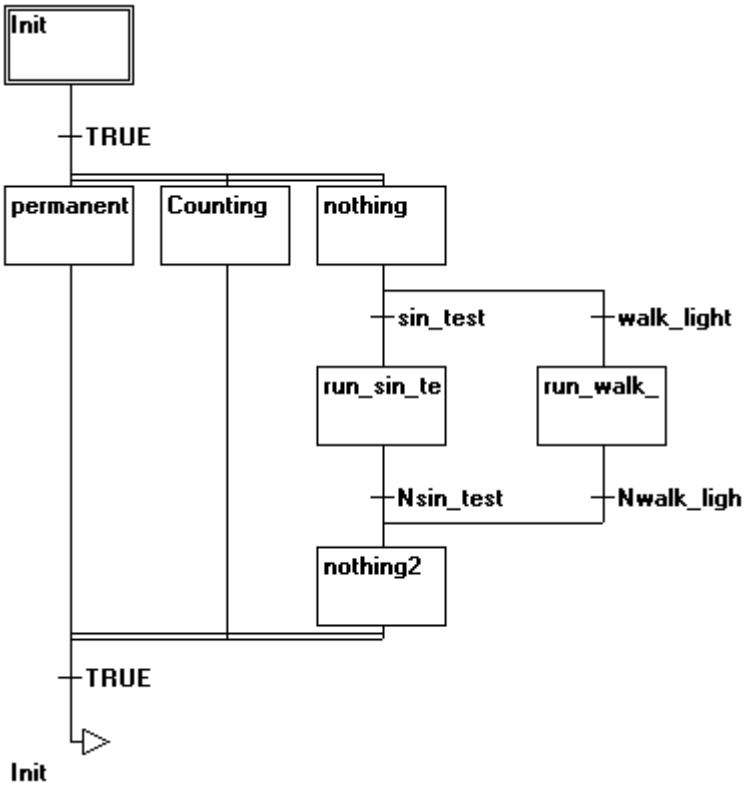
2.4.2.11 EXIT instruction

If the EXIT instruction appears in a FOR, WHILE, or REPEAT loop, then the innermost loop is ended, regardless of the break-off condition.

2.4.3 Sequential Function Chart (SFC)

The Sequential Function Chart is a graphically oriented language which makes it possible to describe the chronological order of different actions within a program.

X Example for a network in the Sequential Function Chart



2.4.3.1 Step

A POU written in a Sequential Function Chart consists of a series of steps which are connected with each other through directed connections (transitions).

There are two types of steps.

- The simplified type consists of an action and a flag which shows if the step is active. If the action of a step is implemented, then a small triangle appears in upper right corner of the step.
- An IEC step consists of a flag and one or more assigned actions or boolean variables. The associated actions appear to the right of the step..

2.4.3.2 Action

An action can contain a series of instructions in IL or in ST, a lot of networks in FBD or in LD, or again in Sequential Function Chart (SFC).

With the simplified steps an action is always connected to a step. In order to edit an action, click twice with the mouse on the step to which the action belongs. Or select the step and select the menu command 'Extras' 'Zoom Action/Transition'. In addition, one input or output action per step is possible.

Actions of IEC steps hang in the Object Organizer directly under their SFC-POU and are loaded with a doubleclick or by pressing <Enter> in their editor. New actions can be created with 'Project' 'Add Action'.

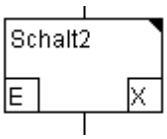
2.4.3.3 Entry or exit action

Additional to a step action you can add an entry action and an exit action to a step. An entry action is executed only once, right after the step has become active. An exit action is executed only once before the step is deactivated.

A step with entry action is indicated by an "E" in the lower left corner, the exit action by an "X" in the lower right corner.

The entry and exit action can be implemented in any language. In order to edit an entry or exit action, doubleclick in the corresponding corner in the step with the mouse.

Example of a step with entry and exit action:



on / Transition condition

Between the steps there are so-called transitions.

A transition condition must have the value TRUE or FALSE. Thus it can consist of either a boolean variable, a boolean address or a boolean constant. It can also contain a series of instructions having a boolean result, either in ST syntax (e.g. (i<= 100) AND b) or in any language desired (see 'Extras' 'Zoom Action/Transition'). But a transition may not contain programs, function blocks or assignments!

Note:
Besides transitions, inching mode can also be used to skip to the next step; see SFCtip and SFCtipmode.

2.4.3.4 Active step

After calling the SFC POU, the action (surrounded by a double border) belonging to the initial stepis executed first. A step, whose action is being executed, is called active. In Online mode active steps are shown in blue.

In a control cycle all actions are executed which belong to active steps. Thereafter the respective following steps of the active steps become active if the transition conditions of the following steps are TRUE. The currently active steps will be executed in the next cycle.

Note:
If the active step contains an output action, this will only be executed during the next cycle, provided that the transition following is TRUE.

2.4.3.5 IEC step

Along with the simplified steps the standard IEC steps in SFC are available.

In order to be able to use IEC steps, you must link the special SFC library **lecsfc.lib** into your project.

Any number of actions can be assigned to an IEC step. IEC actions are not fixed as input, step or output actions to a certain step as in the simplified steps, but are stored separately from the steps and can be reused many times within a POU. For this they must be associated to the single steps with the command **'Extras''Associate action'**.

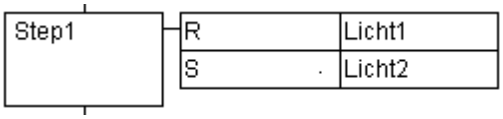
Along with actions, Boolean variables can be assigned to steps.

The activation and deactivation of actions and boolean variables can be controlled using so-called qualifiers. Time delays are possible. Since an action can still be active, if the next step has been processed, for example through the qualifier S (Set), one can achieve concurrent processes.

An associated boolean variable is set or reset with each call of the SFC block. That means, that with each call the value changes from TRUE or FALSE or back again.

The actions associated with an IEC step are shown at the right of the step in a two-part box. The left field contains the qualifier, possibly with time constant, and the right field contains the action name respectively boolean variable name.

An example for an IEC step with two actions:



In order to make it easier to follow the processes, all active actions in online mode are shown in blue like the active steps. After each cycle a check is made to see which actions are active.

Pay attention here also to the restrictions on the use of time-qualifiers in actions that are repeatedly re-used within the same cycle (see 'Qualifier') !

Note:
If an action has been inactivated, it will be executed **once more**. That means, that each action is executed at least twice (also an action with qualifier P).

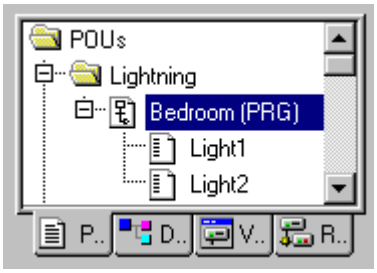
In case of a call first the deactivated actions, then the active actions are executed, in alphabetical order each time.

Whether a newly inserted step is an IEC step depends upon whether the menu command **'Extras' 'Use IEC-Steps'** has been chosen.

In the Object Organizer the actions hang directly underneath their respective SFC POUs. New actions can be created with 'Project' 'Add Action'.

In order to use IEC steps you must include in your project the special SFC library Iecsfc.lib .

X SFC POU with actions in the Object Organizer



2.4.3.6 Qualifier

In order to associate the actions with IEC steps the following qualifiers are available:

N	Non-stored	The action is active as long as the step
R	overriding Reset	The action is deactivated
S	Set (Stored)	The action is activated and remains active until a Reset
L	time Limited	The action is activated for a certain time, maximum as long as the step is active
D	time Delayed	The action becomes active after a certain time if the step is still active and then it remains active as long as the step is active.
P	Pulse	The action is executed just one time if the step is active
SD	Stored and time Delayed	The action is activated after a certain time and remains active until a Reset
DS	Delayed and Stored	The action is activated after a certain time as long as the step is still active and remains active up to a Reset
SL	Stored and time limited	The action is activated for a certain time

The qualifiers L, D, SD, DS and SL need a time value in the TIME constant format.

Note:
When an action has been deactivated it will be **executed once more**. This means that each action at least is executed twice (also an action with qualifier P).

2.4.3.7 Implicit variables in SFC

There are implicitly declared variables in the SFC which can be used.

A flag belongs to each step which stores the state of the step. The step flag (active or inactive state of the step) is called **<StepName>.x** for IEC steps or **<StepName>** for the simplified steps. This Boolean variable has the value TRUE when the associated step is active and FALSE when it is inactive. It can be used in every action and transition of the SFC block.

One can make an enquiry with the variable **<ActionName>.x**. as to whether an IEC action is active or not.

For IEC steps the implicit variables **<StepName>.t** can be used to enquire about the active time of the steps.

Implicit variables can also be accessed by other programs. Example: boolvar1:=sfc1.step1.x; Here, step1.x is the implicit boolean variable representing the state of IEC step step1 in POU sfc1.

2.4.3.8 SFC Flags

If a step is active in SFC for longer than its attributes state, some special flags are set. There are also variables which can be set in order to control the program flow in the sequential function chart. To use the flags it is necessary, globally or locally, to declare them as output or input variables.

SFCEnableLimit: This variable is of the type BOOL. When it has the value TRUE, the timeouts of the steps will be registered in SFCError. Other timeouts will be ignored.

SFCInit: When this boolean variable has the value TRUE the sequential function chart is set back to the Init step. The other SFC flags are reset too (initialization). The Init step remains active, but is not executed, for as long as the variable has the value TRUE. It is only when SFCInit is again set to FALSE that the block can be processed normally.

SFCReset: This variable, of type BOOL, behaves similarly to SFCInit. Unlike the latter, however, further processing takes place after the initialization of the Init step. Thus for example the SFCReset flag could be re-set to FALSE in the Init step.

SFCQuitError: Execution of the SFC diagram is stopped for as long as this boolean variable has the value TRUE whereby a possible timeout in the variable SFCError is reset. All previous times in the active steps are reset when the variable again assumes the value FALSE.

SFCPause: Execution of the SFC diagram is stopped for as long as this boolean variable has the value TRUE.

SFCError: This Boolean variable is TRUE when a timeout has occurred in a SFC diagram. If another timeout occurs in a program after the first one, it will not be registered unless the variable SFCError is reset first.

SFCTrans: This boolean variable takes on the value TRUE when a transition is actuated.

SFCErrorStep: This variable is of the type STRING. If SFCError registers a timeout, in this variable is stored the name of the step which has caused the timeout.

SFCErrorPOU: This variable of the type STRING contains the name of the block in which a timeout has occurred.

SFCCurrentStep: This variable is of the type STRING. The name of the step is stored in this variable which is active, independently of the time monitoring. In the case of simultaneous sequences the step is stored in the branch on the outer right.

No further timeout will be registered if a timeout occurs and the variable SFCError is not reset again.

SFCErrorAnalyzation: This variable, of type STRING, provides the transition expression as well as every variable in an assembled expression which gives a FALSE result for the transition and thus produces a timeout in the preceding step. A requirement for this is declaration of the SFCError flag, which registers the timeout. SFCErrorAnalyzation refers back to a function called AppedErrorString in the analyzation.lib library. The output string separates multiple components with the symbol "|".

SFCTip, **SFCTipMode**: This variables of type BOOL allow inching mode of the SFC. When this is switched on by SFCTipMode=TRUE, it is only possible to skip to the next step if SFCTip is set to TRUE. As long as SFCTipMode is set to FALSE, it is possible to skip even over transitions.

2.4.3.9 Alternative branch

Two or more branches in SFC can be defined as alternative branches. Each alternative branch must begin and end with a transition. Alternative branches can contain parallel branches and other alternative branches. An alternative branch begins at a horizontal line (alternative beginning) and ends at a horizontal line (alternative end) or with a jump.

If the step which precedes the alternative beginning line is active, then the first transition of each alternative branch is evaluated from left to right. The first transition from the left whose transition condition has the value TRUE is opened and the following steps are activated (see active step).

2.4.3.10 Parallel branch

Two or more branches in SFC can be defined as parallel branches. Each parallel branch must begin and end with a step. Parallel branches can contain alternative branches or other parallel branches. A parallel branch begins with a double line (parallel beginning) and ends with a double line (parallel end) or with a jump. It can be provided with a jump label.

If the parallel beginning line of the previous step is active and the transition condition after this step has the value TRUE, then the first steps of all parallel branches become active (see active step). These branches are now processed parallel to one another. The step after the parallel end line becomes active when all previous steps are active and the transition condition before this step produces the value TRUE.

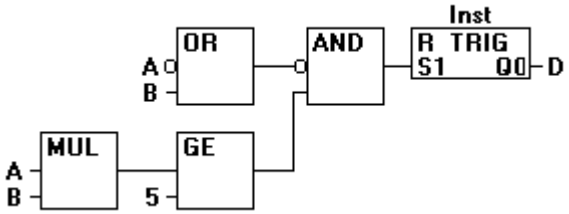
2.4.3.11 Jump

A jump is a connection to the step whose name is indicated under the jump symbol. Jumps are required because it is not allowed to create connections which lead upward or cross each other.

2.4.4 Function Block Diagram (FBD)

The Function Block Diagram is a graphically oriented programming language. It works with a list of networks whereby each network contains a structure which represents either a logical or arithmetic expression, the call of a function block, a jump, or a return instruction.

X Example of a network in the Function Block Diagram



2.4.5 The Continuous Function Chart Editor (CFC)

The continuous function chart editor does not operate like the function block diagram FBD with networks, but rather with freely placeable elements. This allows feedback, for example.

X Example of a network in the continuous function chart editor

2.4.6 Ladder Diagram (LD)

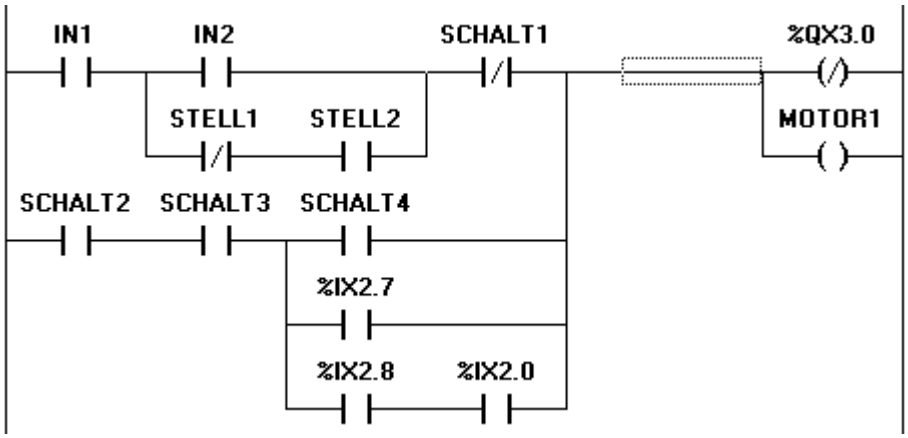
The Ladder Diagram is also a graphics oriented programming language which approaches the structure of an electric circuit.

On the one hand, the Ladder Diagram is suitable for constructing logical switches, on the other hand one can also create networks as in FBD. Therefore the LD is very useful for controlling the call of other POUs.

The Ladder Diagram consists of a series of networks. A network is limited on the left and right sides by a left and right vertical current line. In the middle is a circuit diagram made up of contacts, coils, and connecting lines.

Each network consists on the left side of a series of contacts which pass on from left to right the condition "ON" or "OFF" which correspond to the Boolean values TRUE and FALSE. To each contact belongs a Boolean variable. If this variable is TRUE, then the condition is passed from left to right along the connecting line. Otherwise the right connection receives the value OFF.

X Example of a network in a Ladder Diagram made up of contacts and coils



2.4.6.1 Contact

Each network in LD consists on the left side of a network of *contacts* (contacts are represented by two parallel lines: | |) which from left to right show the condition "On" or "Off".

These conditions correspond to the Boolean values TRUE and FALSE. A Boolean variable belongs to each contact. If this variable is TRUE, then the condition is passed on by the connecting line from left to right, otherwise the right connection receives the value "Out".

Contacts can be connected in parallel, then one of the parallel branches must transmit the value "On" so that the parallel branch transmits the value "On"; or the contacts are connected in series, then contacts must transmit the condition "On" so that the last contact transmits the "On" condition. This therefore corresponds to an electric parallel or series circuit.

A contact can also be negated, recognizable by the slash in the contact symbol: |/|. Then the value of the line is transmitted if the variable is FALSE.

2.4.6.2 Coil

On the right side of a network in LD there can be any number of so-called coils which are represented by parentheses:**( )**. They can only be in parallel. A coil transmits the value of the connections from left to right and copies it in an appropriate Boolean variable. At the entry line the value ON (corresponds to the Boolean variable TRUE) or the value OFF (corresponding to FALSE) can be present.

Contacts and coils can also be negated (in the example the contact SWITCH1 and the coil %QX3.0 is negated). If a coil is negated (recognizable by the slash in the coil symbol: **(/)**), then it copies the negated value in the appropriate Boolean variable. If a contact is negated, then it connects through only if the appropriate Boolean value is FALSE.

2.4.6.3 Function blocks in the Ladder Diagram

Along with contacts and coils you can also enter function blocks and programs In the network they must have an input and an output with Boolean values and can be used at the same places as contacts, that is on the left side of the LD network

2.4.6.4 Set/Reset coils

Coils can also be defined as set or reset coils. One can recognize a set coil by the "S" in the coil symbol: **(S)**) It never writes over the value TRUE in the appropriate Boolean variable. That is, if the variable was once set at TRUE, then it remains so.

One can recognize a reset coil by the "R" in the coil symbol: **(R)**) It never writes over the value FALSE in the appropriate Boolean variable: If the variable has been once set on FALSE, then it remains so.

2.4.6.5 LD as FBD

When working with LD it is very possible that you will want to use the result of the contact switch for controlling other POUs. On the one hand you can use the coils to put the result in a global variable which can then be used in another place. You can, however, also insert the possible call directly into your LD network. For this you introduce a POU with EN input.

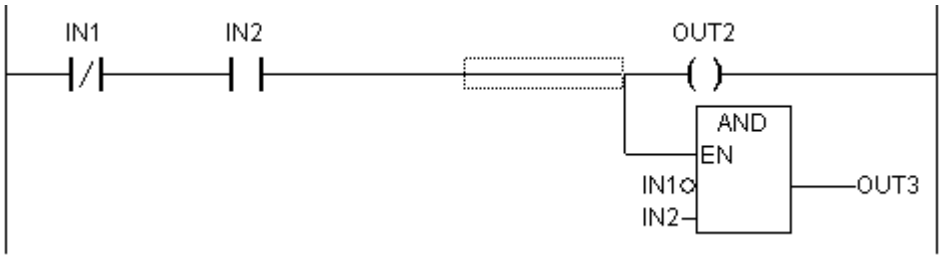
Such POUs are completely normal operands, functions, programs, or function blocks which have an additional input which is labeled with EN. The EN input is always of the BOOL type and its meaning is: The POU with EN input is evaluated when EN has the value TRUE.

An EN POU is wired parallel to the coils, whereby the EN input is connected to the connecting line between the contacts and the coils. If the ON

information is transmitted through this line, this POU will be evaluated completely normally.

Starting from such an EN POU, you can create networks similar to FBD.

X Example of a LD network with an EN POU



2.5 Debugging, Online Functions

2.5.1 Sampling Trace

The Sampling Trace allows you to trace the value sequence of variables, depending upon the so-called trigger event. This is the rising edge or falling edge of a previously defined Boolean variable (trigger variable). **WAGO-I/O-*PRO* 32** permits the tracing of up to 20 variables. 500 values can be traced for each variable.

2.5.2 Debugging

The debugging functions of **WAGO-I/O-*PRO* 32** make it easier for you to find errors.

In order to debug, run the command **'Project' 'Options'** and in the dialog box that pops up under Build options select activate option **Debugging**.

2.5.3 Breakpoint

A breakpoint is a place in the program at which the processing is stopped. Thus it is possible to look at the values of variables at specific places within the program.

Breakpoints can be set in all editors. In the text editors breakpoints are set at line numbers, in FBD and LD at network numbers, in CFC at POUs and in SFC at steps. No breakpoints can be set in function block instances.

2.5.4 Single step

Single step means:

- In IL: Execute the program until the next CAL, LD or JMP command.
- In ST: Execute the next instruction.
- In FBD, LD: Execute the next network.

- In SFC: Continue the action until the next step.

By proceeding step by step you can check the logical correctness of your program.

2.5.5 Single Cycle

If Single cycle has been chosen, then the execution is stopped after each cycle.

2.5.6 Change values online

During operations variables can be set once at a certain value (write value) or also described again with a certain value after each cycle (force value). In online mode one also can change the variable value by double click on the value. By that boolean variables change from TRUE to FALSE or the other way round, for each other types of variables one gets the dialog **Write Variable xy**, where the actual value of the variable can be edited.

2.5.7 Monitoring

In Online mode, all displayable variables are read from the controller and displayed in real time. You will find this display in the declarations and program editor; you can also read out current values of variables in the watch and receipt manager and in a visualization. If variables from instances of function blocks are to be monitored, the corresponding instance must first be opened.

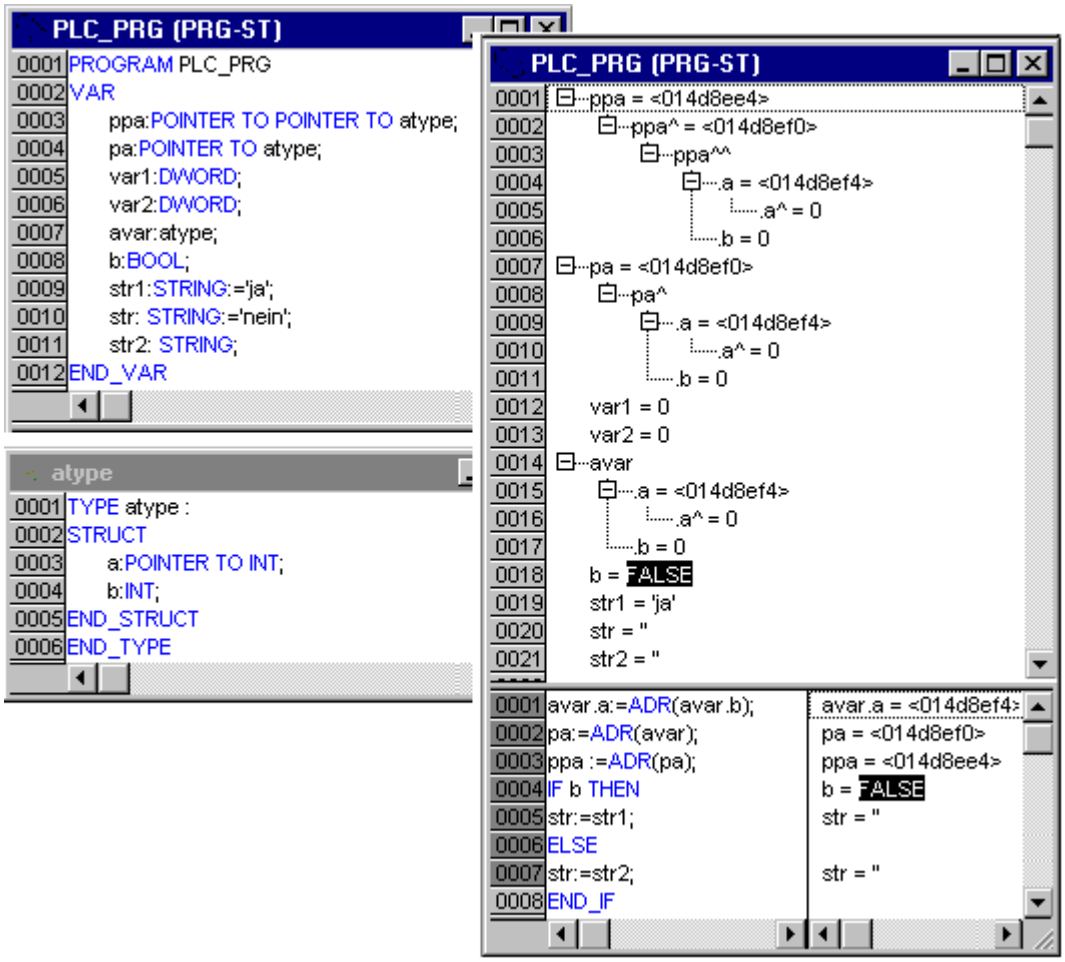
In monitoring VAR_IN_OUT variables, the de-referenced value is output.

In monitoring pointers, both the pointer and the de-referenced value are output in the declaration portion. In the program portion, only the pointer is output:

+ --pointervar = '<'pointervalue'>'

POINTERs in the de-referenced value are also displayed accordingly. With a simple click on the cross or a double-click on the line, the display is either expanded or truncated.

X Example for Monitoring of Pointers



In the implementations, the value of the pointer is displayed. For de-referencing, however, the de-referenced value is displayed.

Monitoring of ARRAY components: In addition to array components indexed by a constant, components are also displayed which are indexed by a variable:

```
anarray[1] = 5

anarray[i] = 1
```

If the index consists of an expression (e.g. [i+j] or [i+1]), the component can not be displayed.

2.5.8 Simulation

During the simulation the created PLC program is not processed in the PLC, but rather in the calculator on which **WAGO-I/O-*PRO* 32** is running. All online functions are available. That allows you to test the logical correctness of your program without PLC hardware.

2.5.9 Log

The log chronologically records user actions, internal processes, state changes and exceptions during Online mode processing. It is used for monitoring and for error tracing (see Online Functions).

2.6 The Standard

The standard IEC 61131-3 is an international standard for programming languages of Programmable Logic Controllers.

The programming languages offered in **WAGO-I/O-*PRO* 32** conform to the requirements of the standard.

According to this standard, a program consists of the following elements:

- Structures (see chapter Data Types of the Online Help chapters)
- POUs
- Global Variables

The general language elements are described in the sections Identifier, Addresses, Types, Comments, and Constants.

The processing of a **WAGO-I/O-*PRO* 32** program starts with the special POU PLC_PRG. The POU PLC_PRG can call other POUs.

3 Programming Example

Let us now start to write a small example program. It is for a simple traffic signal unit which is supposed to control two traffic signals at an intersection. The red/green phases of both traffic signals alternate and, in order to avoid accidents, we will insert yellow or yellow/red transitional phases. The latter will be longer than the former.

3.1 Controlling a Traffic Signal Unit

In this example you will see how time dependent programs can be shown with the language resources of the IEC1131-3 standard, how one can edit the different languages of the standard with the help of **WAGO-I/O-*PRO* 32**, and how one can easily connect them while becoming familiar with the simulation of **WAGO-I/O-*PRO* 32**.

3.1.1 Create POU

Starting always is easy: Start **WAGO-I/O-*PRO* 32** and choose 'File' 'New'.

In the dialog box which appears, the first POU has already been given the default name PLC_PRG. Keep this name, and the type of POU should definitely be a program. Each project needs a program with this name. In this case we choose as the language of this POU the Continuous Function Chart Editor (CFC)

Now create three more objects with the command 'Project' 'Object Add' with the menu bar or with the context menu (press right mouse button in the Object Organizer). A program in the language Sequential Function Chart (SFC) named SEQUENCE, a function block in the language Function Block Diagram (FBD) named TRAFFICSIGNAL, along with a POU WAIT, also of the type function block, which we want to program as an Instruction List (IL).

3.1.2 What does TRAFFICSIGNAL do?

In the POU TRAFFICSIGNAL we will assign the individual trafficsignal phases to the lights, i.e. we will make sure that the red light is lit red in the red phase and in the yellow/red phase, the yellow light in the yellow and yellow/red phases, etc.

3.1.3 What does WAIT do?

In WAIT we will program a simple timer which as input will receive the length of the phase in milliseconds, and as output will produce TRUE as soon as the time period is finished.

3.1.4 What does SEQUENCE do?

In SEQUENCE all is combined so that the right light lights up at the right time for the desired time period.

3.1.5 What does PLC_PRG do?

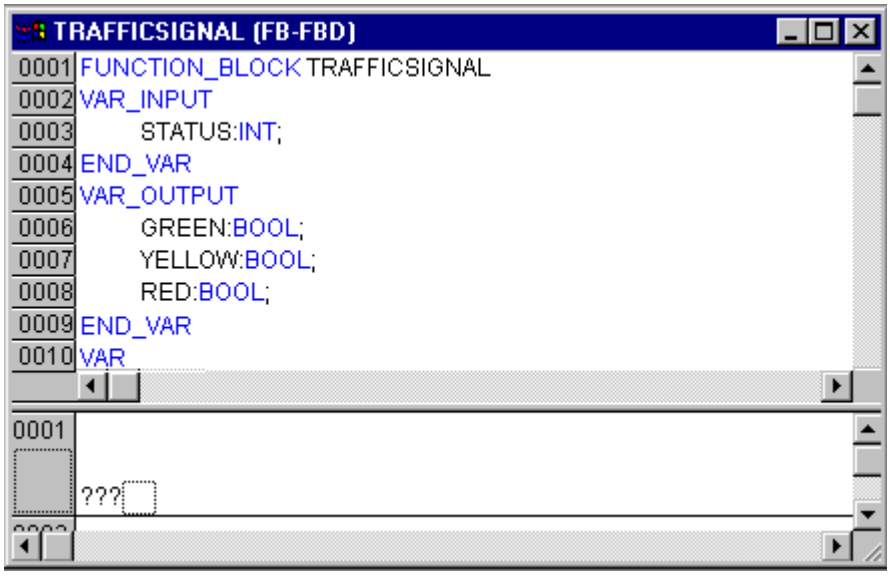
In PLC_PRG the input start signal is connected to the traffic lights' sequence and the "color instructions" for each lamp are provided as outputs.

3.1.6 "TRAFFICSIGNAL" declaration

Let us now turn to the POU TRAFFICSIGNAL. In the declaration editor you declare as input variable (between the keywords VAR_INPUT and END_VAR) a variable named STATUS of the type INT. STATUS will have four possible conditions, that is one for the TRAFFICSIGNAL phases green, yellow, yellow/red andred.

Correspondingly our TRAFFICSIGNAL has three outputs, that is RED, YELLOW and GREEN. You should declare these three variables. Then the declaration part of our function block TRAFFICSIGNAL will look like this:

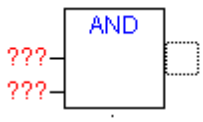
X Function block TRAFFICSIGNAL, declaration part



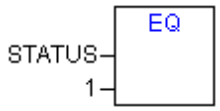
3.1.7 "TRAFFICSIGNAL" body

Now we determine the values of the output variables depending on the input STATUS of the POU. To do this go into the body of the POU. Click on the field to the left beside the first network (the gray field with the number 1). You have now selected the first network. Choose the menu item 'Insert' 'Box'.

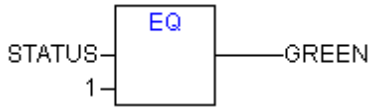
In the first network a box is inserted with the operator AND and two inputs:



Click on the text AND with the mouse pointer and change the text into EQ. Select the three question marks from the upper of the two inputs and enter the variable STATUS. Then select the lower of the three question marks and put a 1 underneath it. You get the following network:



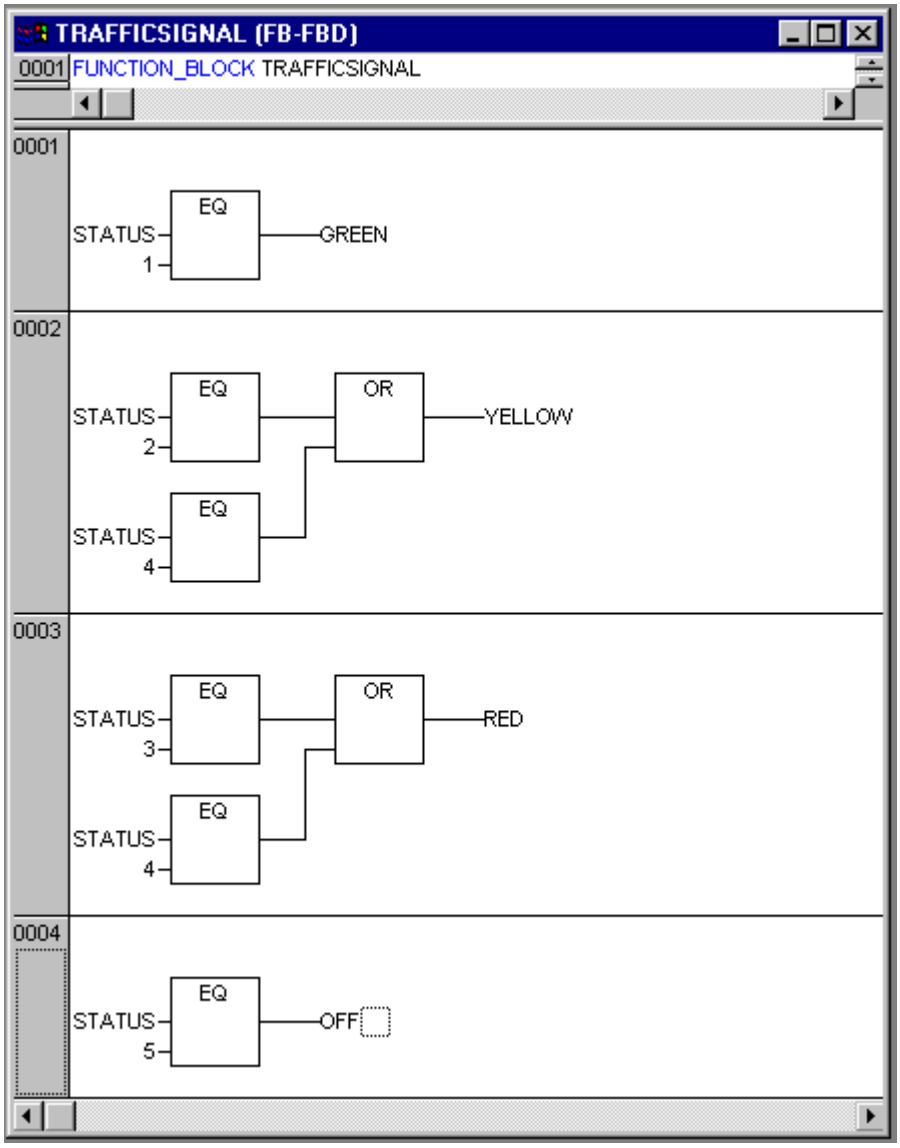
Click now on a place behind the EQ Box. Now the output of the EQ operation is selected. Choose 'Insert' 'Assign'**.** Change the three question marks ??? to GREEN. You now have created a network with the following structure:



STATUS is compared with 1, the result is assigned to GREEN. This network thus switches to GREEN if the preset state value is 1.

For the other TRAFFICSIGNAL colors we need two more networks. You create them with the command 'Insert' 'Network (after)'. These networks should be set up as in the example. The finished POU now looks like follows:

X Function block TRAFFICSIGNAL, instruction part



In order to insert an operator in front of another operator, you must select the place where the input to which you want to attach the operator feeds into the box.

Then use the command 'Insert' 'Box'. Otherwise you can set up these networks in the same way as the first network.

Now our first POU has been finished. TRAFFICSIGNAL, according to the input of the value STATUS, controls whichever light color we wish.

3.1.8 Connecting the standard.lib

For the timer in the POU WAIT we need a POU from the standard library. Therefore, open the library manager with **'Window' 'Library Manager**. Choose 'Insert' 'Additional library'. The dialog box appears for opening files. From the list of the libraries choose standard.lib.

3.1.9 "WAIT" declaration

Now let us turn to the POU WAIT. This POU is supposed to become a timer with which we can determine the length of the time period of each TRAFFICSIGNAL phase. Our POU receives as input variable a variable TIME of the type TIME, and as output it produces a Boolean value which we want to call OK and which should be TRUE when the desired time period is finished. We set this value with FALSE by inserting at the end of the declaration (before the semicolon, however) " := FALSE ".

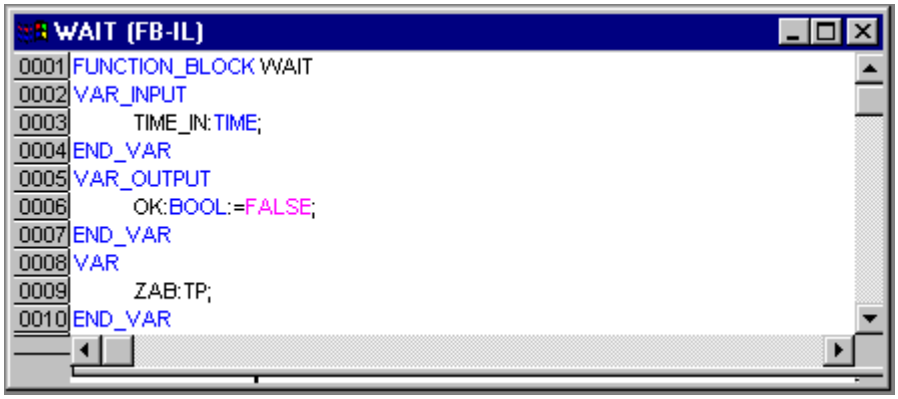
For our purposes we need the POU TP, a clock generator. This has two inputs (IN, PT) and two outputs (Q, ET). TP does the following:

As long as IN is FALSE, ET is 0 and Q is FALSE. As soon as IN provides the value TRUE, the time is calculated at the output ET in milliseconds. When ET reaches the value PT, then ET is no longer counted. Meanwhile Q produces TRUE as long as ET is smaller than PT. As soon as the value PT has been reached, then Q produces FALSE again. In addition you will find a short description of all POUs from the standard library in the appendix.

In order to use the POU TP in the POU WAIT we must create a local instance from TP. For this we declare a local variable ZAB (for elapsed time) of the type TP (between the keywords VAR, END_VAR).

The declaration part of WAIT thus looks like this:

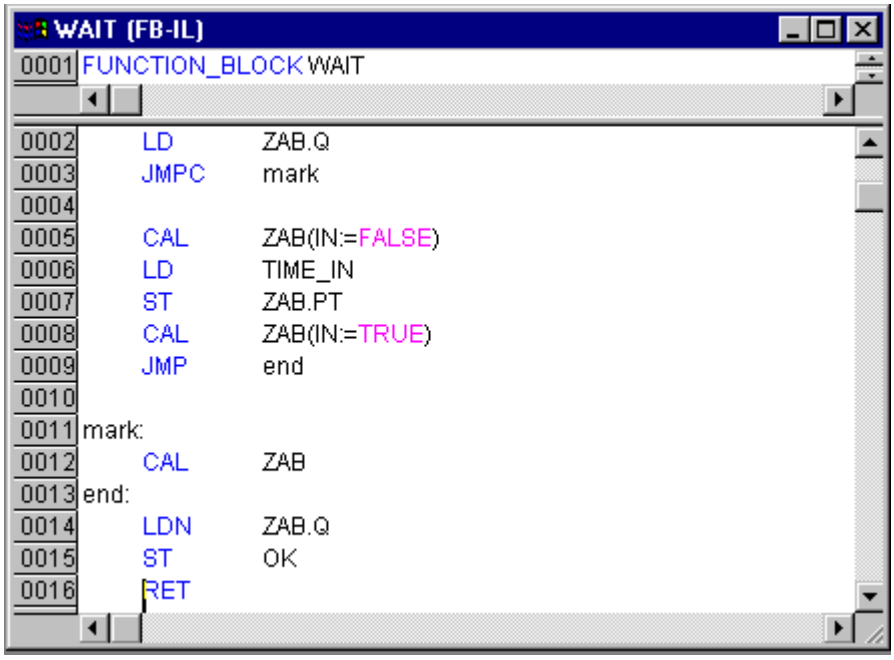
X Function Block WAIT, Declaration Part



3.1.10 "WAIT" body

In order to create the desired timer, the body of the POU must be programmed as follows:

X Function Block WAIT, Instruction Part



At first it is checked whether Q has already been set at TRUE (as though the counting had already been executed), in this case we change nothing with the occupation of ZAB, but we call the function block ZAB without input (in order to check whether the time period is already over).

Otherwise we set the variable IN in ZAB at FALSE, and therefore at the same time ET at 0 and Q at FALSE. In this way all variables are set at the desired initial condition. Now we assign the necessary time from the variable TIME into the variable PT, and call ZAB with IN:=TRUE. In the function block ZAB the variable ET is now calculated until it reaches the value TIME, then Q is set at FALSE.

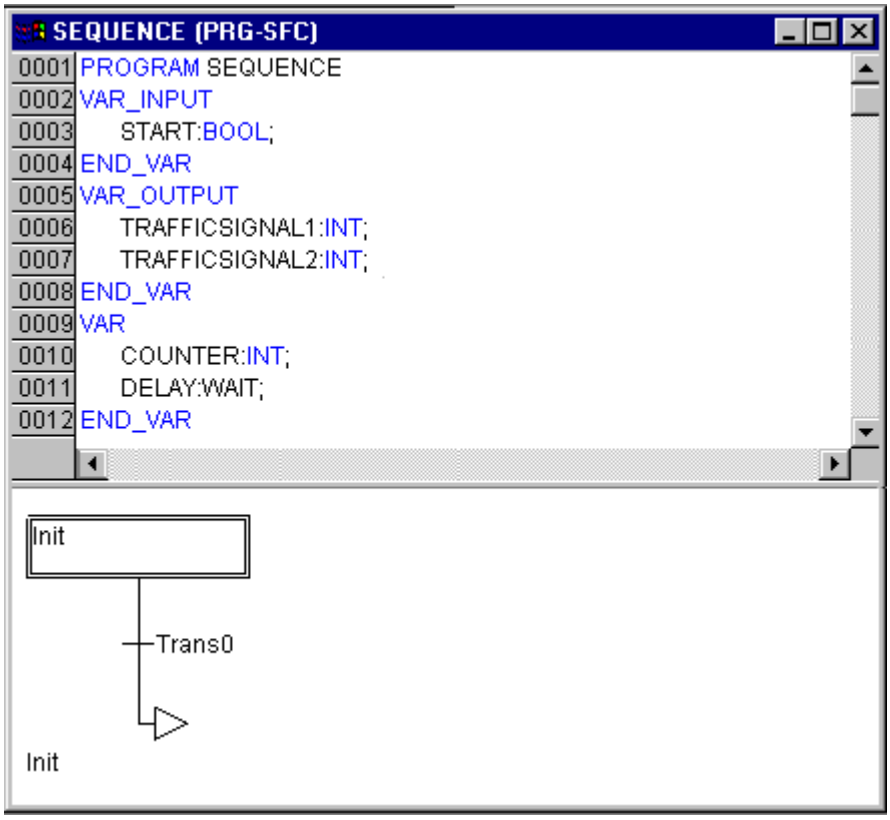
The negated value of Q is saved in OK after each execution of WAIT. As soon as Q is FALSE, then OK produces TRUE.

The timer is finished at this point. Now it is time to combine our two function blocks WAIT and TRAFFICSIGNAL in the main program PLC_PRG.

3.1.11 "SEQUENCE" first expansion level

First we declare the variables we need. They are: an input variable START of the type BOOL, two output variables TRAFFICSIGNAL1 and TRAFFICSIGNAL2 of the type INT and one of the type WAIT (DELAY as delay). The program SEQUENCE now looks like shown here:

X Program Sequence, First Expansion Level, Declaration Part



3.1.12 Create a SFC diagram

The beginning diagram of a POU in SFC always consists of an action "Init" of a following transition "Trans0" and a jump back to Init. We have to expand that.

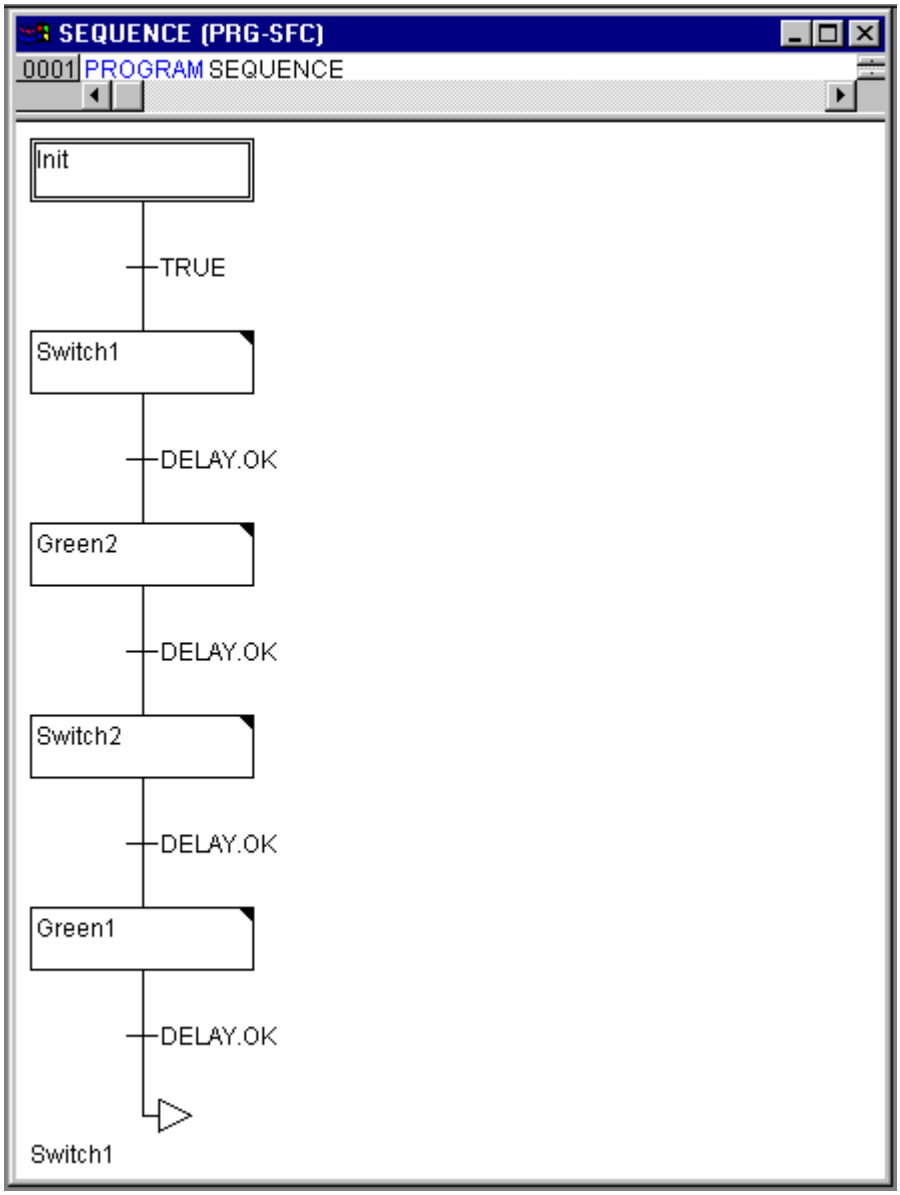
Before we program the individual action and transitions let us first determine the structure of the diagrams. We need one step for each TRAFFICSIGNAL phase. Insert it by marking Trans0 and choosing 'Insert' 'Step transition (after)'. Repeat this procedure three more times.

If you click directly on the name of a transition or a step, then this is marked and you can change it. Name the first transition after Init "START", and all other transitions "DELAY.OK".

The first transition switches through when START is TRUE and all others switch through when DELAY in OK produces TRUE, i.e. when the set time period is finished.

The steps (from top to bottom) receive the names Switch1, Green2, Switch2, Green1, whereby Init of course keeps its Name. "Switch" should include a yellow phase, at Green1 TRAFFICSIGNAL1 will be green, at Green2 TRAFFICSIGNAL2 will be green. Finally change the return address of Init after Switch1. If you have done everything right, then the diagram should look like in the following image:

X Program SEQUENCE, First Expansion Level, Instruction Part

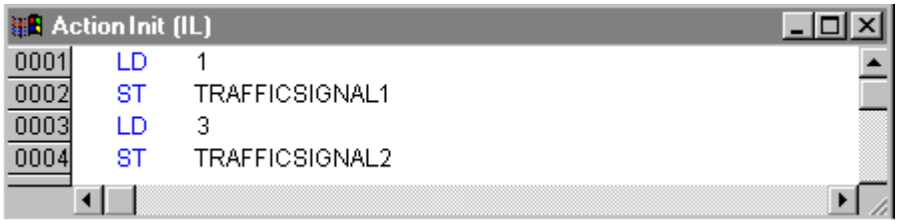


Now we have to finish the programming of the individual steps. If you doubleclick on the field of a step, then you get a dialog for opening a new action. In our case we will use IL (Instruction List).

3.1.13 Actions and transition conditions

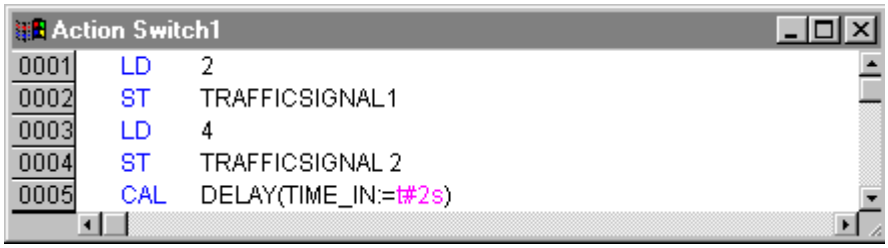
In the action of the step **Init** the variables are initialized, the STATUS of TRAFFICSIGNAL1 should be 1 (green). The state of TRAFFICSIGNAL2 should be 3 (red). The action Init then looks like in the following image:

X Action Init



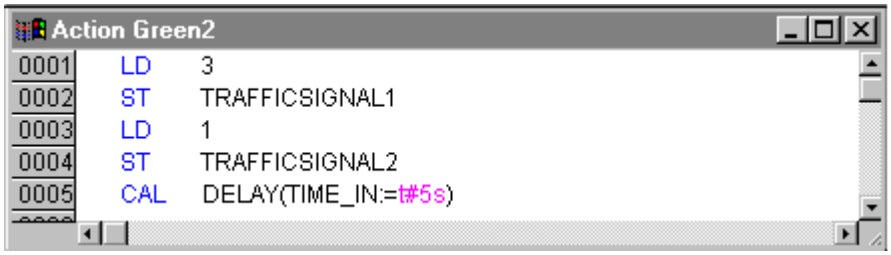
Switch1 changes the sate of TRAFFICSIGNAL1 to 2 (yellow), and that of TRAFFICSIGNAL2 to 4 (yellow-red). In addition, a time delay of 2000 milliseconds is set. The action is now as follows:

X Action Switch1



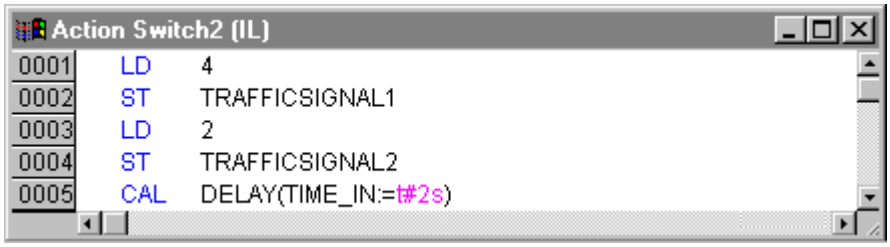
With **Green2** TRAFFICSIGNAL1 is red (STATUS:=3), TRAFFICSIGNAL2 green (STATUS:=1), and the delay time is 5000 milliseconds.

X Action Green2



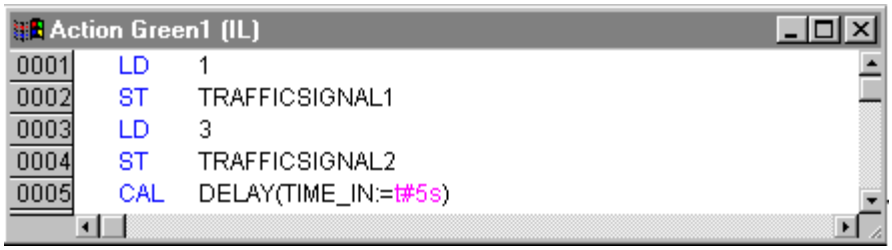
At **Switch2** the STATUS of TRAFFICSIGNAL1 changes to 4 (yellow-red), that of TRAFFICSIGNAL2 to 2 (yellow). A time delay of 2000 milliseconds is now set.

X Action Switch2



With **Green1** TRAFFICSIGNAL1 is green (STATUS:=1), TRAFFICSIGNAL2 is red (STATUS:=3), and the time delay is set to5000 milliseconds.

X Action Green1



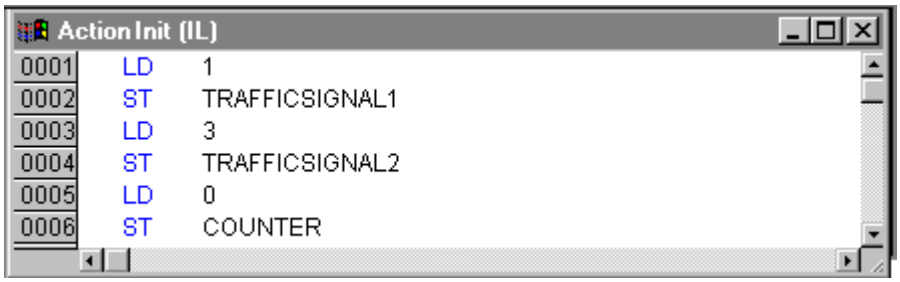
The first expansion phase of our program is completed. Now you can compile it and also test the simulation.

3.1.14 "SEQUENCE" second expansion level

In order to ensure that our diagram has at least one alternative branch, and so that we can turn off our traffic light unit at night, we now include in our program a counter which, after a certain number of TRAFFICSIGNAL cycles, turns the unit off.

At first we need a new variable COUNTER of the type INT. Declare this as usual in the declaration part of PLC_PRG, and initialize it in Init with 0.

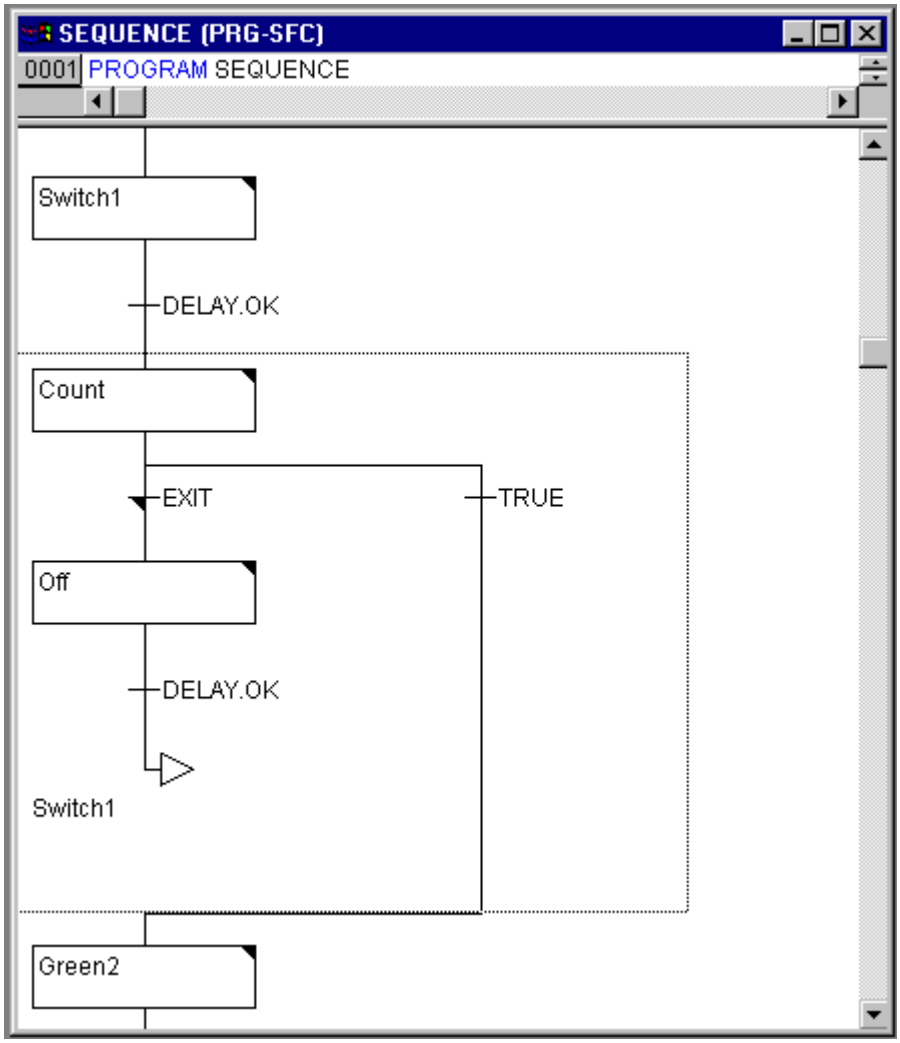
X Action Init, Second Version



Now select the transition after Switch1 and insert a step and then a transition. Select the resulting transition and insert an alternative branch to its left. After the left transition insert a step and a transition. After the resulting new transition insert a jump after Switch1.

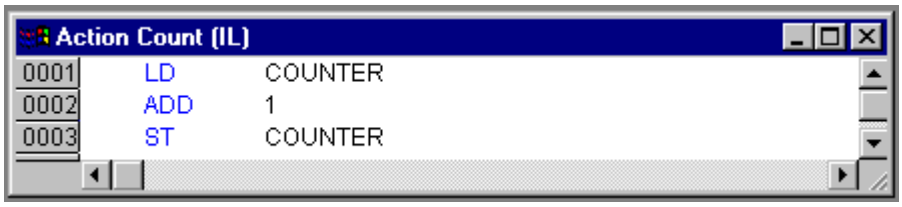
Name the new parts as follows: the upper of the two new steps should be called "Count" and the lower "Off". The transitions are called (from top to bottom and from left to right) EXIT, TRUE and DELAY.OK. The new part should look like the part marked with the black border in the following image:

X Program SEQUENCE, Second Expansion Level, Instruction Part



Now two new actions and a new transition condition are to be implemented. At the step Count the variable COUNTER is increased by one:

X Action Count

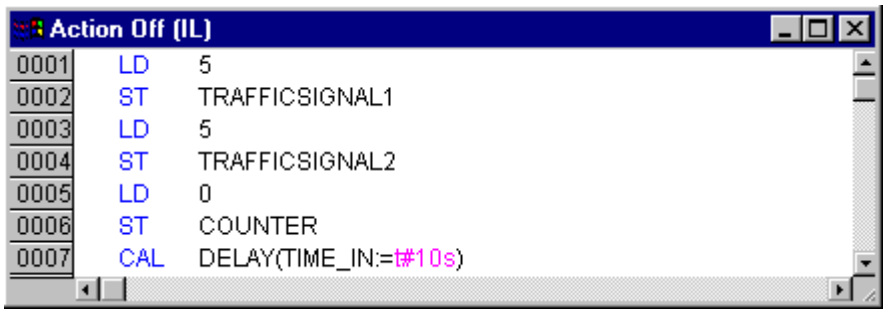


The EXIT transition checks whether the counter is greater than a certain value, for example 7:

X Transition EXIT

At Off the state of both lights is set at 5(OFF), (or each other number not equal 1,2,3 or 4) the COUNTER is reset to 0, and a time delay of 10 seconds is set:

X Action Off



3.1.15 The result

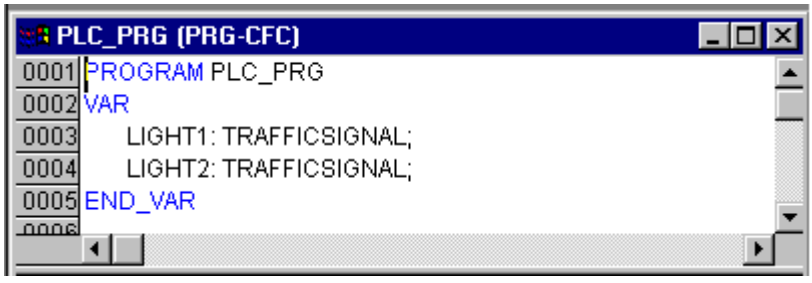
In our hypothetical situation, night falls after seven TRAFFICSIGNAL cycles, for ten seconds the TRAFFICSIGNAL turns itself off, then we have daylight again, the traffic light unit turns itself on again, and the whole process starts again from the beginning.

3.1.16 PLC_PRG

We have defined and correlated the time sequencing of the phases for both sets of traffic lights in the block SEQUENCE. Since, however, we see the traffic lights system as a module of a bus system, e.g. CAN bus, we have to make input and output variables available in the block PLC_PRG. We want to start-up the traffic lights system over an ON switch and we want to send each of the six lamps (each traffic light red, green, yellow) the corresponding "signal command" for each step of the SEQUENCE. We are now declaring appropriate Boolean variables for these six outputs and one input, before we create the programme in the editor, and are allocating them, at the same time, to the corresponding IEC addresses.

The next step is declare the variables Light1 and Light2 of the type Phases in the declaration editor.

X Declaration LIGHT1 and LIGHT2



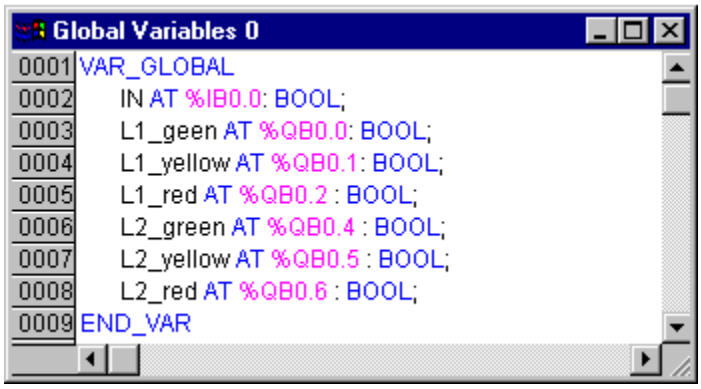
These deliver the Boolean value of each of the six lights to the above mentioned six outputs for each step of the block SEQUENCE. We are not, however, declaring the output variables which are foreseen within the

PLC_PRG block but under Resources for Global Variables instead. The Boolean input variable IN, which is used to set the variable START in the block SEQUENCE to TRUE, can be set in the same way. ON is also allocated to an IEC address.

Select the tab Resources and open the list Global Variables.

Make the declaration as follows:

X Declaration of the Input-/Output Variables for a CAN-Configuration


Global Variables 0
0001 VAR_GLOBAL
0002 IN AT %IB0.0: BOOL;
0003 L1_geen AT %QB0.0: BOOL;
0004 L1_yellow AT %QB0.1: BOOL;
0005 L1_red AT %QB0.2 : BOOL;
0006 L2_green AT %QB0.4 : BOOL;
0007 L2_yellow AT %QB0.5 : BOOL;
0008 L2_red AT %QB0.6 : BOOL;
0009 END_VAR

The name of the variable (e.g. IN) is followed, after AT, by a percent sign which begins the IEC address. I stands for input, Q for output, B (used in this example) stands for byte and the individual bits of the module are addressed using 0.0 (0.1, 0.2, etc.). We will not do the needed controller configuration here in this example, because it depends on which target package you have available on your computer. Please see PLC configuration for further information.

We now want to finish off the block PLC_PRG.

For this we go into the editor window. We have selected the Continuous Function Chart editor and we consequently obtain, under the menu bar, a CFC symbol bar with all of the available elements (see The Continuous Function Chart Editor).

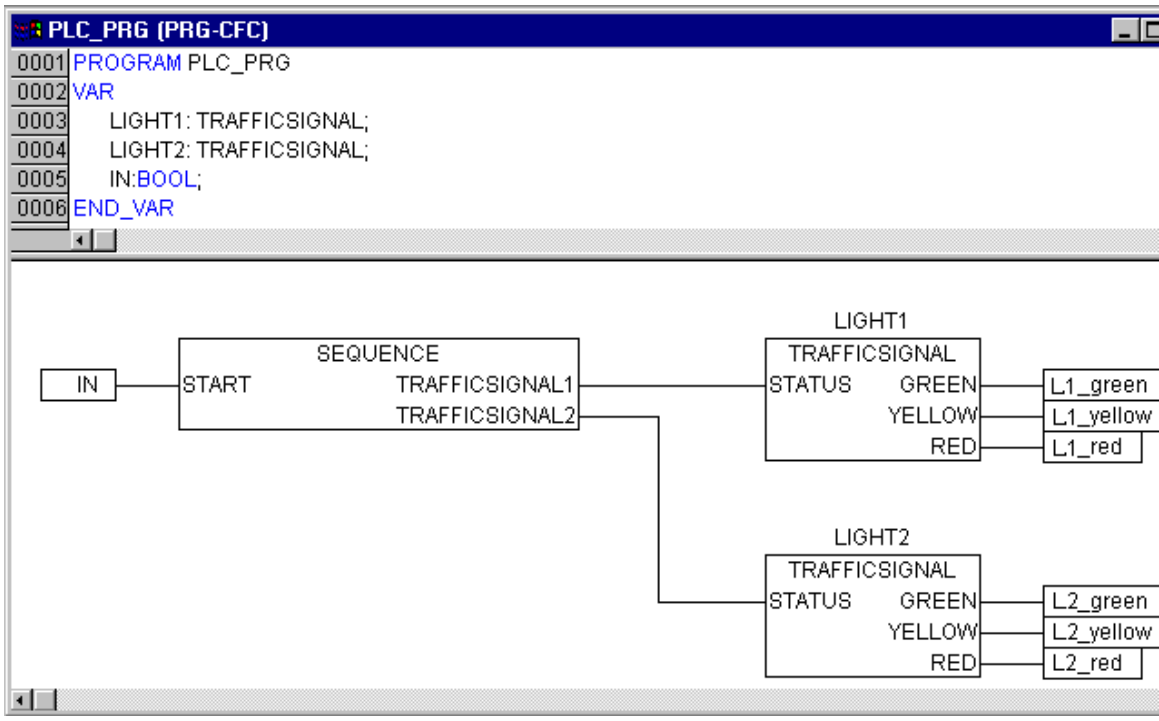
Click on the right mouse key in the editor window and select the element **Box**. Click on the text AND and write "SEQUENCE" instead. This brings up the block SEQUENCE with all of the already defined input and output variables. Insert two further block elements which you name PHASES. Phases is a function block and this causes you to obtain three red question marks over the block which you replace with the already locally declared variables LIGHT1 and LIGHT2. Now set an element of the type **Input**, which award the title ON and six elements of the type **Output** which you award variable names to, as described, namely L1_green, L1_yellow, L1_red, L2_green, L2_yellow, L2_red.

All of the elements of the programme are now in place and you can connect the inputs and outputs, by clicking on the short line at the input/output of an

element and dragging this with a constantly depressed mouse key to the input/output of the desired element.

Your program should finally look like the example shown here.

X PLC_PRG, Declaration and presentation with the continuous function chart editor



3.1.17 TRAFFICSIGNAL simulation

Now test your program. For this you must compile it ('Project' 'Rebuild all') login ('Online' 'Login' and then load it 'Online' 'Download'). If you now select 'Online' 'Run', the chronological order of the individual steps of your main program can be followed. The window of the POU PLC_PRG has now changed to the monitor window. Click twice on the plus sign in the declaration editor, the variable display drops down, and you can see the values of the individual variables.

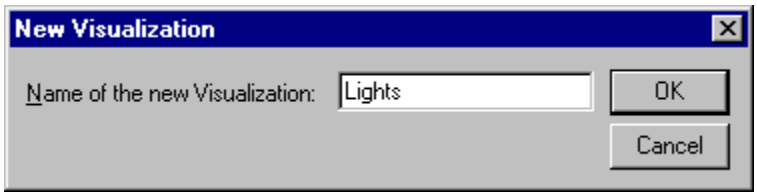
3.2 Visualizing a Traffic Signal Unit

With the visualization of **WAGO-I/O-*PRO* 32** you can quickly and easily bring project variables to life. We will now plot two traffic signals and an ON-Switch for our traffic light unit which will illustrate the switching process.

3.2.1 Creating a new visualization

In order to create a visualization you must first select the range of **Visualization** in the Object Organizer. First click on the lower edge of the window on the left side with the **POU** on the register card with this symbol

and the name **Visualization**. If you now choose the command 'Project' 'Object Add', then a dialog box opens.



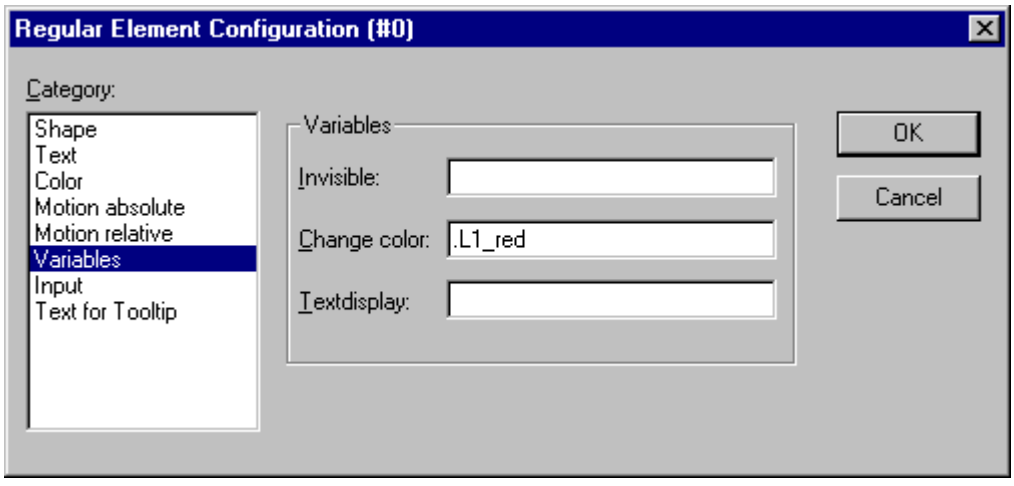
Enter here any name. When you confirm the dialog with **OK**, then a window opens in which you can set up your new visualization.

3.2.2 Insert element in Visualization

For our TRAFFICSIGNAL visualization you should proceed as follows:

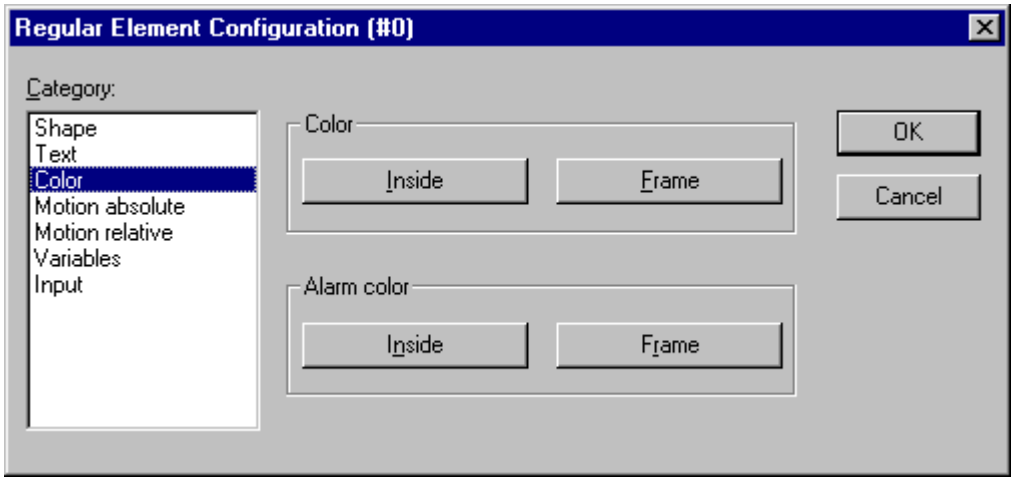
- Give the command 'Insert' 'Ellipse' and try to draw a medium sized circle (∅2cm). For this click in the editor field and draw with pressed left mouse button the circle in its length.
- Now doubleclick the circle. The dialog box for editing visualization elements opens
- Choose the category **Variables** and enter in the field **Change color** the variable name .L1_red or choose this variable using the input assistance (button <F2>). This addresses the variable RED of the function block instance TRAFFICSIGNAL1 of the POU PLC_PRG.

X Visualization Dialog Box Variables



- Then choose the category **Color** and click on the button **Inside** in the area **Color**. Choose as neutral a color as possible, such as black.
- Now click on the button **within** in the area **Alarm color** and choose the red which comes closest to that of a red light.

X Visualization Configuration Dialog Box (Color category)



The resulting circle will normally be black, and when the variable RED from TRAFFICSIGNAL1 is TRUE, then its color will change to red. We have therefore created the first light of the first TRAFFICSIGNAL!

3.2.3 The other traffic lights

Now enter the commands 'Edit' 'Copy' (<Ctrl>+<C>) and then twice 'Edit' 'Paste' (<Ctrl>+<V>). That gives you two more circles of the exact same size lying on top of the first one. You can move the circles by clicking on the circle and dragging it with pressed left mouse button. The desired position should, in our case, be in a vertical row in the left half of the editor window. Doubleclick on one of the other two circles in order to open the configuration dialog box again. Enter in the field Change Color of the corresponding circle the following variables:

for the middle circle: L1_yellow

for the lowest circle: L1-green

Now choose for the circles in the category **Color** and in the area **Alarm color** the corresponding color (yellow or green).

3.2.4 The TRAFFICSIGNAL case

Now enter the command 'Insert' 'Rectangle', and insert in the same way as the circle a rectangle which encloses the three circles. Once again choose as neutral a color as possible for the rectangle and give the command **'Extras' 'Send to back'** so that the circles are visible again.

If simulation mode[1] is not yet turned on, you can activate it with the command 'Online' 'Simulation'.

If you now start the simulation with the commands 'Online' 'Login' and 'Online' 'Run', then you can observe the color change of the first traffic signal.

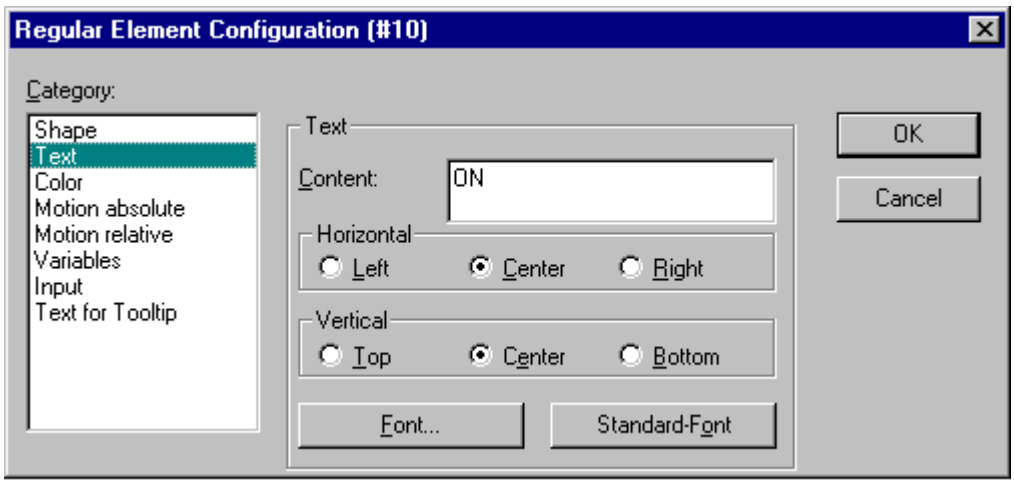
3.2.5 The second traffic signal

The simplest way to create the second traffic signal is to copy all of the elements of the first traffic signal. For this you select all elements of the first traffic signal and copy them (as before with the lights of the first traffic signal) with the commands **'Edit' 'Copy'** and **'Edit' 'Paste'**. You then only have to change the text "TRAFFICSIGNAL1" in the respective dialog boxes into "TRAFFICSIGNAL2", and the visualization of the second traffic signal is completed.

3.2.6 The ON switch

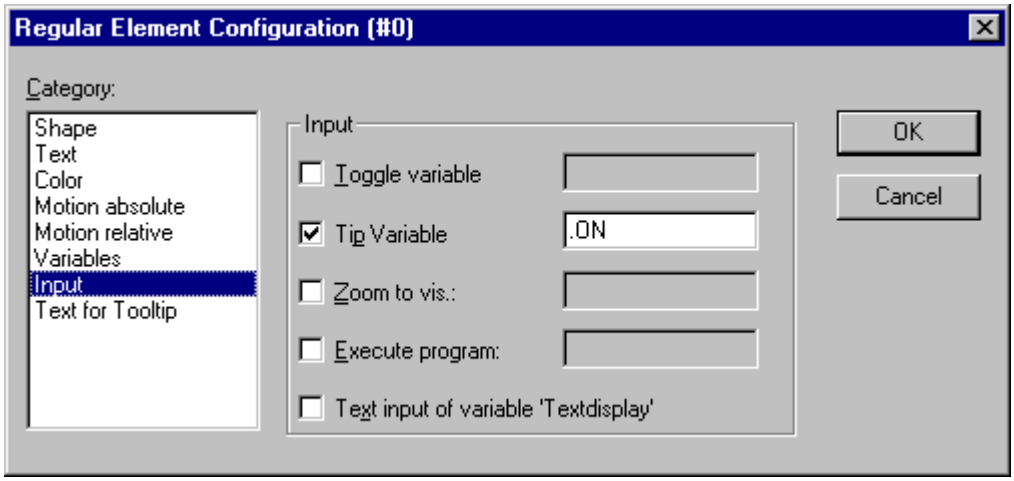
Insert a rectangle and award it, as described above, a colour for a traffic light of your choice and enter .ON at **Variables** for the **Change color**. Enter "ON" in the input field for **Content** in the category Text.

X Dialog to configure the visualization elements (Category Text)



In order to set the variable ON to TRUE with a mouse click on the switch, the variable .ON must be entered into the category **Variables**. Also select the Option Variable keying and enter the variable .ON at this point. Variable keying means that when a mouse click is made on the visualization element the variable .ON is set to the value TRUE but is reset to the value FALSE when the mousekey is released again (we have created hereby a simple switch-on device for our traffic lights program).

X Dialog to configure the visualization elements (Category Input)

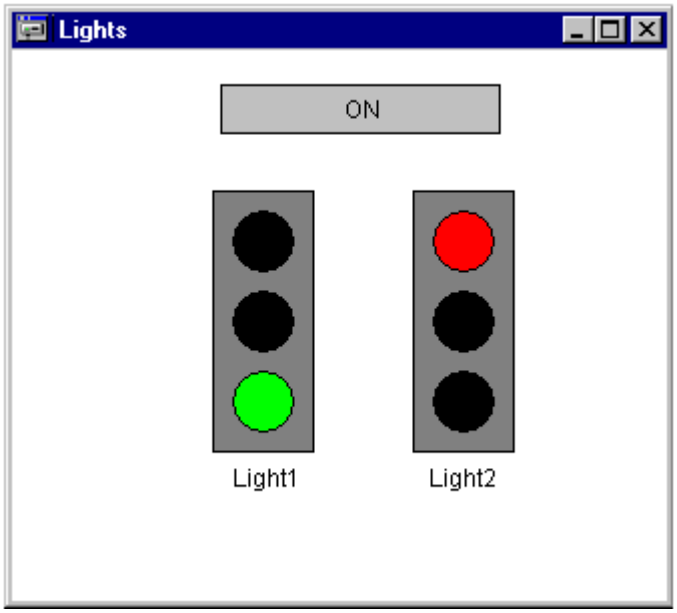


3.2.7 Font in the visualization

In order to complete the visualization you should first insert two more rectangles which you place underneath the traffic signals.

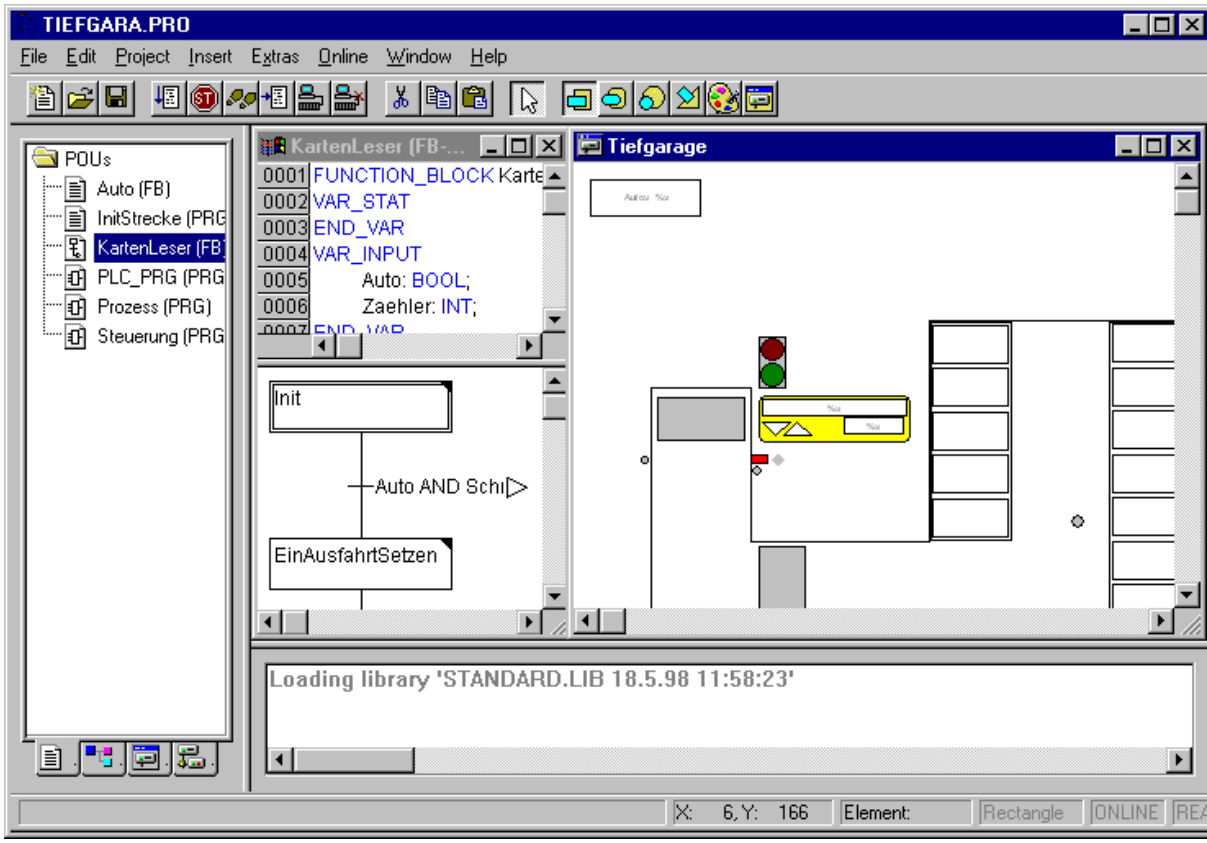
In the visualizations dialog box set white in the category **Color** for **Frame** and write in the category **Text** in the field **Contents** "Light1" or "Light2". Now your visualization looks like this:

X Visualization for the Sample Project Trafficsignal



4 Components of WAGO-I/O-PRO 32

4.1 The Main Window

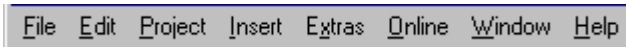


The following elements are found in the main window of **WAGO-I/O-*PRO* 32** (from top to bottom):

- The Menu bar
- The Tool bar (optional); with buttons for faster selection of menu commands.
- The Object Organizer with register cards for POUs, Data types, Visualizations, and Resources
- A vertical screen divider between the Object Organizer and the Work space of WAGO-I/O-*PRO* 32
- The Work space in which the editor windows are located
- The Message window (optional)
- The Status bar (optional); with information about the current status of the project

4.1.1 Menu bar

The menu bar is located at the upper edge of the main window. It contains all menu commands.



4.1.2 Tool bar

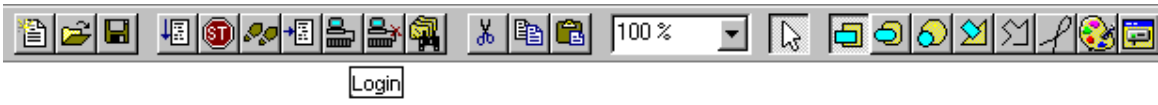
By clicking with the mouse on a symbol you can select a menu command more quickly. The choice of the available symbols automatically adapts itself to the active window.

The command is only carried out when the mouse button is pressed on the symbol and then released.

If you hold the mouse pointer for a short time on a symbol in the tool bar, then the name of the symbol is shown in a Tooltip.

In order to see a description of each symbol on the tool bar, select in Help the editor about which you want information and click on the tool bar symbol in which you are interested.

The display of the tool bar is optional (see 'Project' 'Options' category Desktop).

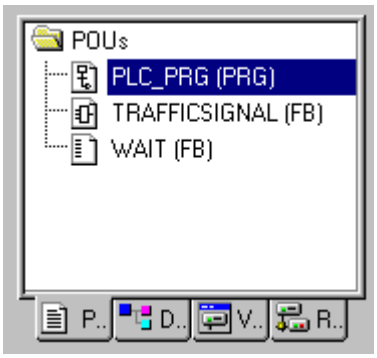


4.1.3 Object Organizer

The Object Organizer is always located on the left side of **WAGO-I/O-*PRO* 32**. At the bottom there are four register cards with symbols for the four types of objects

POUs, **Data types**, Visualizations and Resources**.** In order to change between the respective object types click with the mouse on the corresponding register card or use the left or right arrow key.

You will learn in chapter Managing Objects in a Project how to work with the objects in the Object Organizer.



4.1.4 Screen divider

The screen divider is the border between two non-overlapping windows. In **WAGO-I/O-*PRO* 32** there are screen dividers between the Object Organizer and the Work space of the main window, between the interface (declaration part) and the implementation (instruction part) of POUs and between the Work space and the message window.

You can move the screen divider with the mouse pointer. You do this by moving the mouse with the left mouse button pressed.

Make sure the screen divider always remains at its absolute position, even when the window size has been changed. If it seems that the screen divider is no longer present, then simply enlarge your window.

4.1.5 Work space

The Work space is located on the right side of the main window in **WAGO-I/O-*PRO* 32**. All editors for objects and the library manager are opened in this area. The current object name appears in the title bar; in the case of POUs an abbreviation for the POU type and the programming language currently in use appears in brackets after it.

You find the description of the editors in the chapter The Editors

Under the menu item **'Window'** you find all commands for window management.

4.1.6 Message window

The message window is separated by a screen divider underneath the work space in the main window.

It contains all messages from the previous compilations, checks or comparisons. Search results and the cross-reference list can also be output here.

If you doubleclick with the mouse in the message window on a message or press <Enter>, the editor opens with the object. The relevant line of the object is selected. With the commands 'Edit' 'Next error' and 'Edit' 'Previous error' you can can quickly jump between the error messages.

The display of the message window is optional (see 'Window' 'Messages').

4.1.7 Status bar

The status bar at the bottom of the window frame of the main window in **WAGO-I/O-*PRO* 32** gives you information about the current project and about menu commands.

If an item is relevant, then the concept appears on the right side of the status bar in black script, otherwise in gray script.

When you are working in online mode, the concept **Online** appears in black script. If you are working in the offline mode it appears in gray script.

In Online mode you can see from the status bar whether you are in the simulation (**SIM**), the program is being processed (**RUNS**), a breakpoint is set (**BP**), or variables are being forced (**FORCE**).

With text editor the line and column number of the current cursor position is indicated (e.g. **Line:5, Col.:11**). In online mode '**OV**' is indicated black in the status bar. Pressing the <Ins> key switches between Overwrite and Insert mode.

If the mouse point is in a visualization, the current **X** and **Y position** of the cursor in pixels relative to the upper left corner of the screen is given. If the mouse pointer is on an **Element**, or if an element is being processed, then its number is indicated. If you have an element to insert, then it also appears (e.g. **Rectangle**).

If you have chosen a menu command but haven't yet confirmed it, then a short description appears in the status bar.

The display of the statusbar is optional (see 'Project' 'Options' category Desktop).

4.1.8 Context Menu

Shortcut: <Shift>+<F10>

Instead of using the menu bar for executing a command, you can use the right mouse button. The menu which then appears contains the most frequently used commands for a selected object or for the active editor. The choice of the available commands adapts itself automatically to the active window. The choice of the available commands adapts itself automatically to the active window.

4.2 Options

About **WAGO-I/O-*PRO* 32** there can be of course only one viewpoint. In **WAGO-I/O-*PRO* 32**, however, you can configure the view of the main window (and have more than one viewpoint). In addition you can make other settings. For this you have the command 'Project' 'Options' at your disposal. The settings you make thereby are, unless determined otherwise, saved in the file "**WAGO-I/O-*PRO* 32**.ini" and restored at the next **WAGO-I/O-*PRO* 32** startup.

4.2.1 'Project' 'Options'

With this command the dialog box for setting options is opened. The options are divided into different categories. Choose the desired category on the left side of the dialog box by means of a mouse click or using the arrow keys and change the options on the right side.

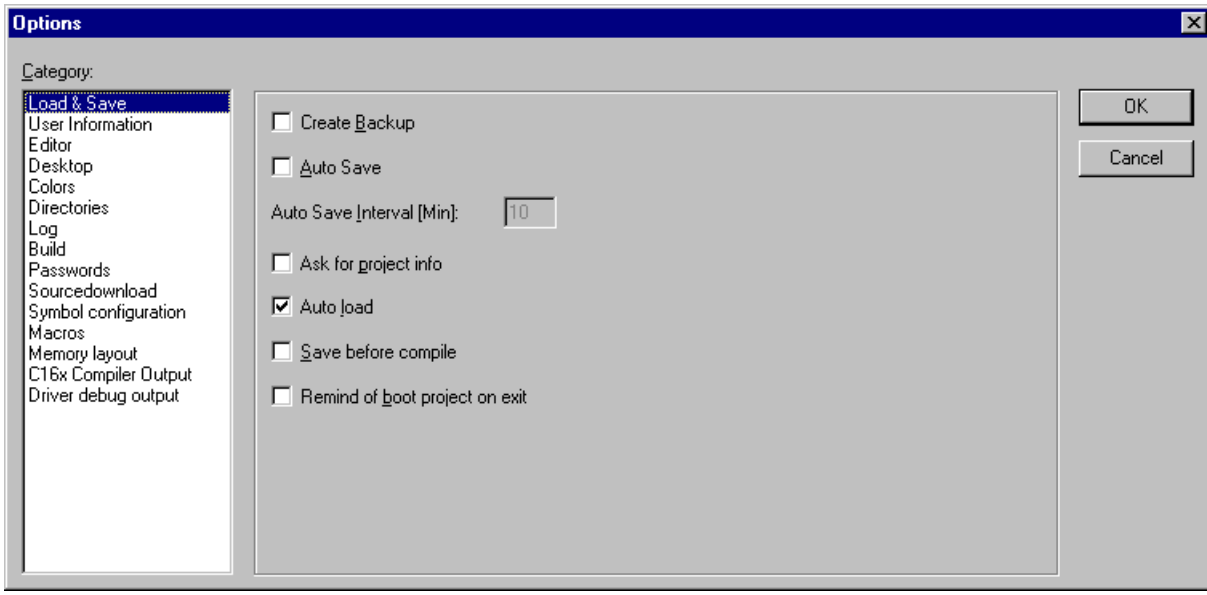
You have at your disposal the following categories:

- Load & Save
- User information
- Editor
- Desktop
- Color
- Directories
- Log
- Build
- Passwords
- Sourcedownload
- Symbol configuration
- Macros

4.2.2 Options for Load & Save

If you choose this category in the Options dialog box , then you get the following dialog box:

X Option dialog box of the category Load & Save

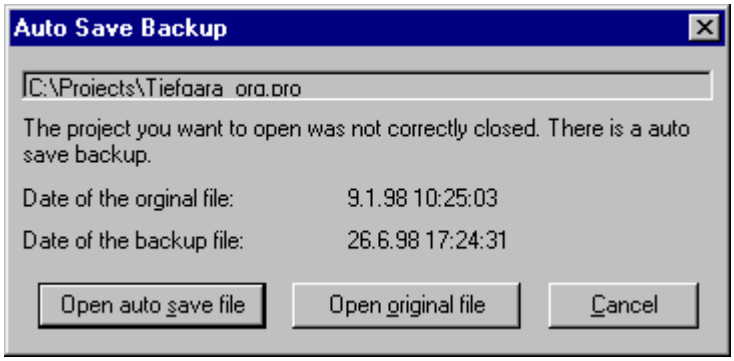


When activating an option, a check (✓) appears before the option.

If you choose the option **Create Backup**, then **WAGO-I/O-*PRO* 32** creates a backup file at every save with the extension ".bak". In this way you can always restore the versions before the last save.

If you choose the option **Auto Save** , then while you work your project is constantly saved to a temporary file with the extension ".asd" according to a set time interval (**Auto Save Interval**). This file is erased at a normal exit from the program. If for any reason **WAGO-I/O-*PRO* 32** is not shut down "normally" (e.g. due to a power failure), then the file is not erased. When you open the file again the following message appears:

X There is an auto save backup.


Auto Save Backup
C:\Projects\Tiefgara_org.pro
The project you want to open was not correctly closed. There is a auto save backup.
Date of the orginal file:
9.1.98 10:25:03
Date of the backup file:
26.6.98 17:24:31
Open auto save file
Open original file
Cancel

You can now decide whether you want to open the original file or the auto save file.

Ask for project info: When saving a new project or saving a project under a new name, the project info is automatically called. You can visualize the project info with the command 'Project' 'Project info' and also process it.

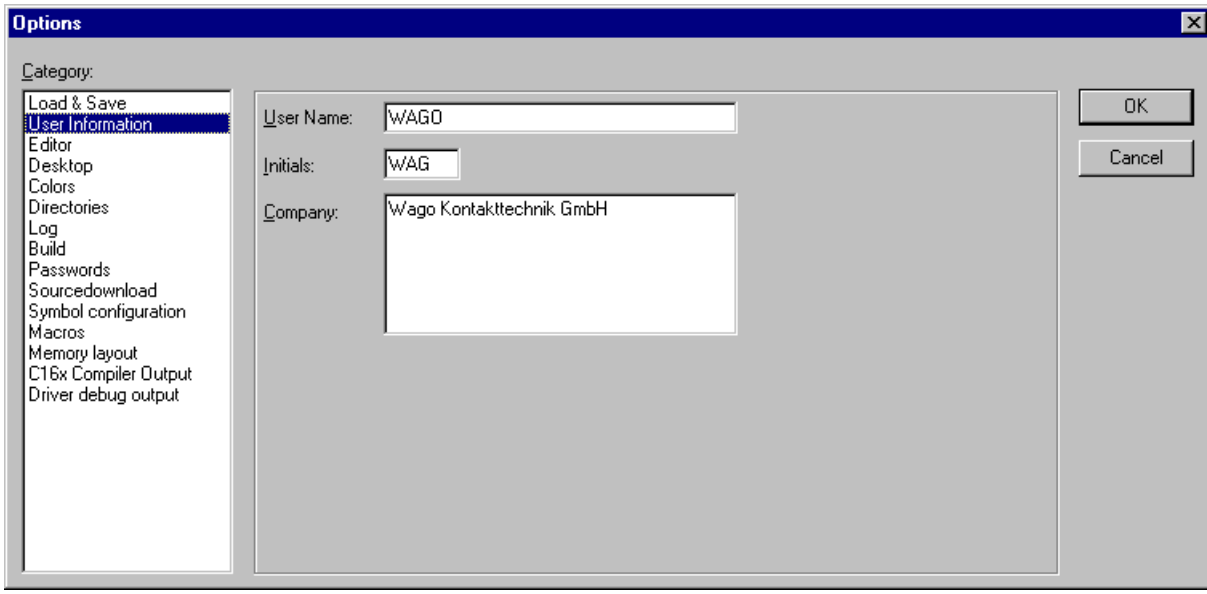
Auto Load: At the next start of **WAGO-I/O-*PRO* 32** the last open project is automatically loaded. The loading of a project at the start of **WAGO-I/O-*PRO* 32** can also take place by entering the project in the command line.

Save before compile: The project is saved before each compilation.

4.2.3 Options for User information

If you choose this category in the Options dialog box, then you get the following dialog box:

X Options dialog box of the category User information

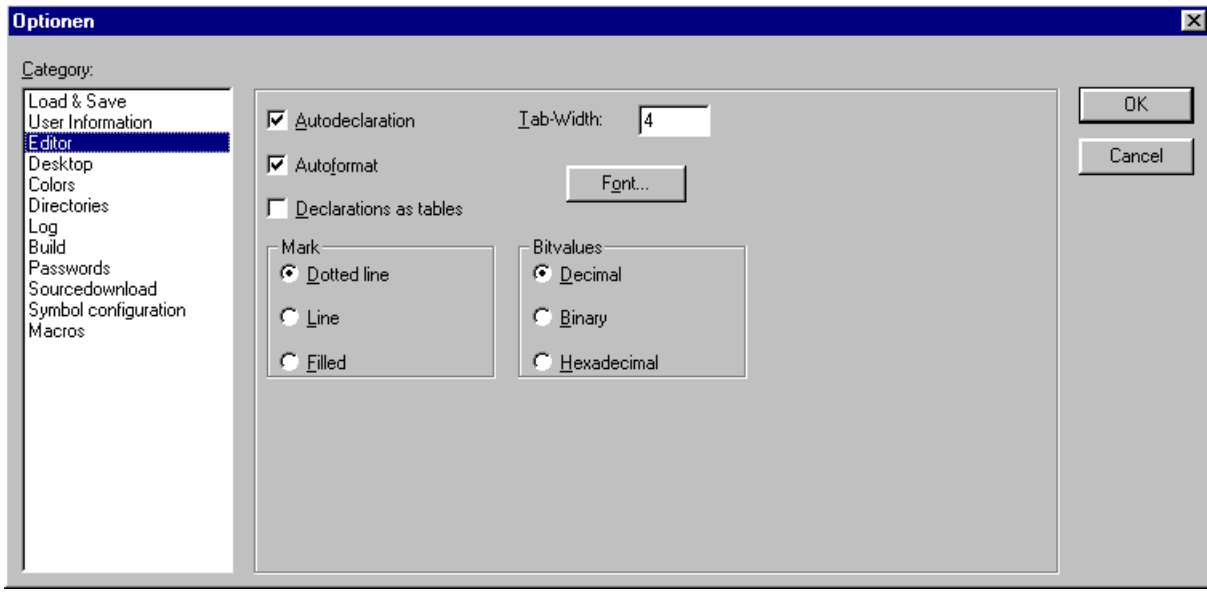


To User information belong the **Name** of the user, his **Initials** and the **Company** for which he works. Each of the entries can be modified.

4.2.4 Options for Editor

If you choose this category in the Options dialog box, then you get the following dialog box:

X Options dialog box of the category Editor



When activating an option, a check (✓) appears before the option.

You can make the following settings for the Editors:

- Autodeclaration
- Autoformat

- Declaration as table
- Tab width
- Font
- Display of the text selection (Mark)
- Display of the Bitvalues

4.2.4.1 Autodeclaration

If you have chosen the **Autodeclaration** option in the Editor category of the options dialog box, then (following the input of a not-yet-declared variable) a dialog box will appear in all editors with which this variable can be declared.

When an option is activated, a check appears in front of it.

4.2.4.2 Autoformat

If the option **Autoformat** in the category Editor of the options dialog box has been chosen, then **WAGO-I/O-*PRO* 32** executes automatic formatting in the IL editor and in the declaration editor. When you finish with a line, the following formatting is made:

- Operators written in small letters are shown in capitals;
- Tabs are inserted to that the columns are uniformly divided.

When an option is activated, a check appears in front of it.

4.2.4.3 Declarations as tables

If the option Declarations as tables in the **Editor** category in Options dialog box is selected, then you can edit variables in a table instead of using the usual declaration editor .

All editors for POUs (Program Organization Units) consist of a declaration part and a body. These are separated by a screen divider that can be dragged, as required, by clicking it with the mouse and moving it up or down. The body can consist of other a text or a graphic editor; the declaration portion is always a text editor.

4.2.4.4 Print margins

The vertical and horizontal margins that apply when the editor contents are printed, are shown by red dashed lines if the **'Show print range'** option in the project options in the dialog **'Workspace'** was selected. The properties of the printer that was entered apply, as well as the size of the print layout selected in the 'File' 'Printer Setup' menu. If no printer setup or no print layout is entered, a default configuration is used (Default.DFR and default printer). The horizontal margins are drawn as if the options 'New page for each object' or 'New page for each sub-object' were selected in 'Documentation settings'. The lowest margin is not displayed.

Note:
An exact display of the print margins is only possible when a zoom factor

of 100% is selected.

4.2.4.5 Comment

User comments must be enclosed in the special symbol sequences "(*" and "*)". Example: (*This is a comment.*)

Comments are allowed in all text editors, at any location desired, that is in all declarations, the IL and ST languages and in self-defined data types. If the Project is printed out using a template, the comment that was entered during variable declaration appears in text-based program components after each variable.

In the FBD and LD graphic editors, comments can be entered for each network. To do this, search for the network on which you wish to comment and activate **'Insert' 'Comment'.** In CFC there are special comment POUs which can be placed at will.

In SFC, you can enter comments about a step in the dialog for editing step attributes.

Nested comments are also allowed if the appropriate option in the 'Project' 'Options' 'Build Options' dialog is activated.

In Online mode, if you rest the mouse cursor for a short time on a variable, the type and if applicable the address and comment of that variable are displayed in a tooltip.

Declaration Editor). This table is arranged as a card-index box in which there are register cards for input, output, local, and input/output variables. For each variable you have available the fields **Name**, **Address**, **Type**, **Initial**, and **Comment**.

When an option is activated, a check appears in front of it.

4.2.4.6 Tab-Width

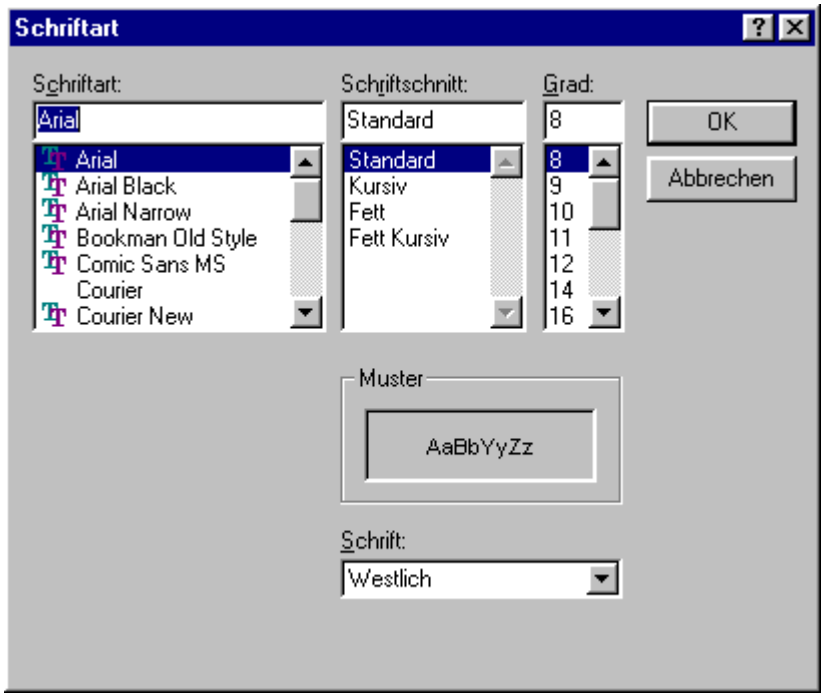
In the field **Tab-Width** in the category Editor of the Options dialog box you can determine the width of a tab as shown in the editors. The default setting is four characters, whereby the character width depends upon the font which is chosen.

4.2.4.7 Font

By clicking on the button **Font** in the category Editor of the Options dialog box you can choose the font in all **WAGO-I/O-*PRO* 32** editors. The font size is the basic unit for all drawing operations. The choice of a larger font size thus enlarges the printout, even with each editor of **WAGO-I/O-*PRO* 32**.

After you have entered the command, the font dialog box opens for choosing the font, style and font size.

X Dialog box for setting the font



4.2.4.8 Mark

When choosing **Mark** in the Editor category in the Options dialog box you can choose whether the current selection in your graphic editors should be represented by a dotted rectangle (**Dotted**), a rectangle with continuous lines (**Line**) or by a filled-in rectangle (**Filled**). In the last case the selection is shown inverted.

The selection is activated in front of which a (•) point appears.

4.2.4.9 Bitvalues

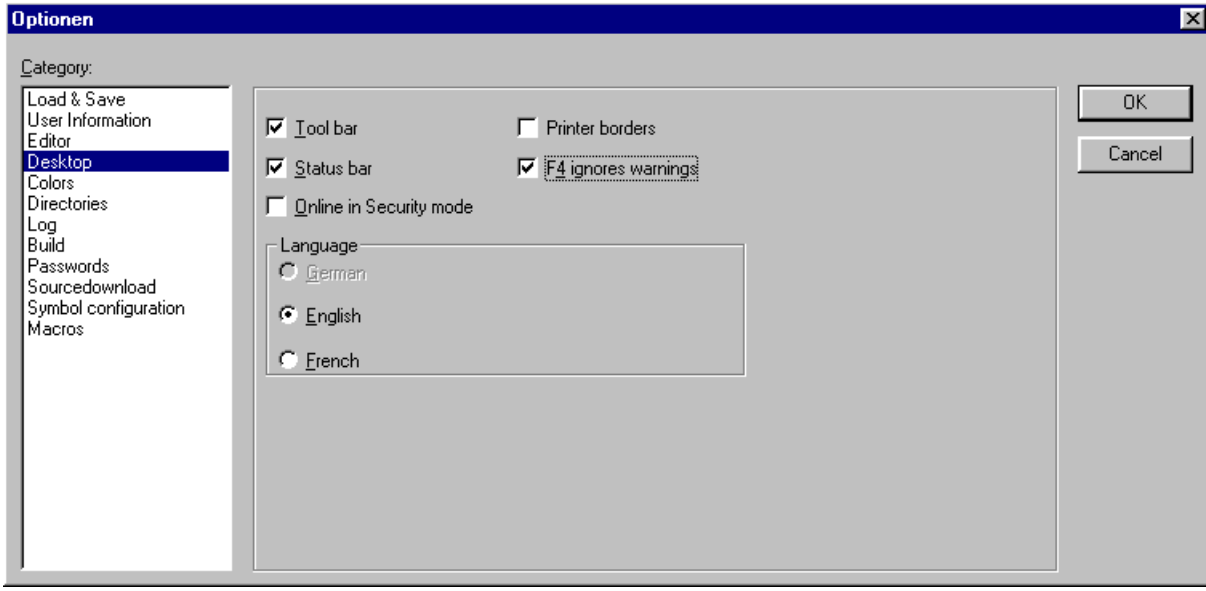
When choosing **Bitvalues** in the category Editor of the Options dialog box you can choose whether binary data (type BYTE, WORD, DWORD) during monitoring should be shown **Decimal**, **Hexadecimal**, or **Binary**.

The selection is activated in front of which a (•) point appears.

4.2.5 Options for the Desktop

If you choose this category in the Options dialog box, then you get the following dialog box:

X Options dialog box of the category Desktop



Tool bar: The tool bar with the buttons for faster selection of menu commands becomes visible underneath the menu bar.

Status bar: The status bar at the lower edge of the **WAGO-I/O-*PRO* 32** main window becomes visible.

Online in Security mode: In Online mode with the commands 'Run', 'Stop', 'Reset' 'Toggle Breakpoint', 'Single cycle', 'Write values', 'Force values' and 'Release force', a dialog box appears with the confirmation request whether the command should really be executed. This option is saved with the project.

Display print ranges: In every editor window, the limits of the currently set print range are marked with red dashed lines. Their size depends on the printer characteristics (paper size, orientation) and on the size of the "Content" field of the set print layout (menu: 'File" "Documentation Settings").

F4 ignores warnings: After compilation, when F4 is pressed in a message window, the focus jumps only to lines with error messages; warning messages are ignored.

Language: Define here, in which language the menu and dialog texts should be displayed.

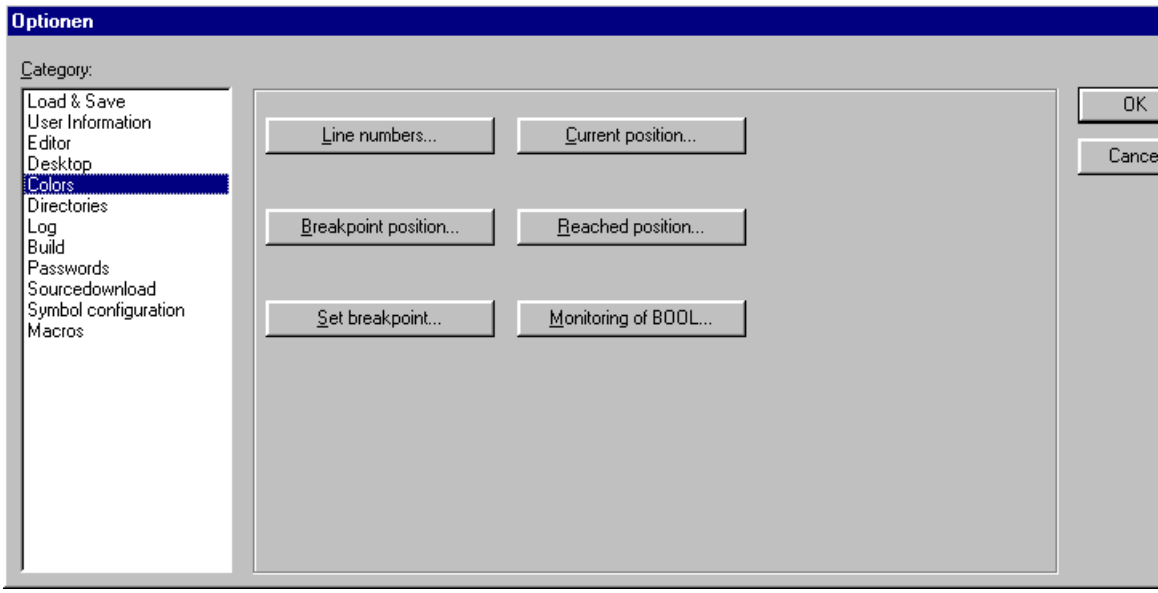
Note:
Please note, that the language choice is only possible under Windows NT !

When an option is activated, a check appears in front of it.

4.2.6 Options for Colors

If you choose this category in the Options dialog box , then you get the following dialog box:

X Options dialog box of the category Color



You can edit the default color setting of **WAGO-I/O-*PRO* 32**. You can choose whether you want to change the color settings for **Line numbers** (default presetting: light gray), for **Breakpoint positions** (dark gray), for a **Set breakpoint** (light blue), for the **Current position** (red), for the **Reached Positions** (green) or for the **Monitoring of Boo**lean values (blue).

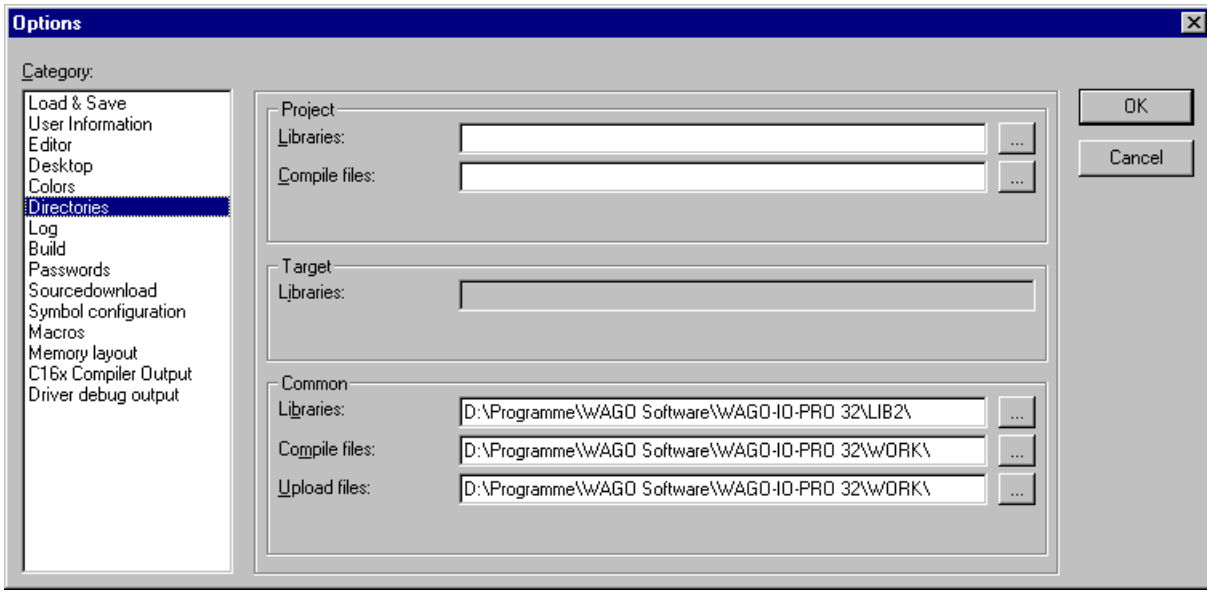
If you have chosen one of the indicated buttons, the dialog box for the input of colors opens.

X Dialog box for setting colors

4.2.7 Options for Directories

If you choose this category in the Options dialog box, then you get the following dialog box:

X Options dialog box of the category Directories



Directories can be entered in the **Project** and **Common** areas for **WAGO-I/O-*PRO* 32** to use in searching for **libraries** and controller **configuration** files, as well as for storing **compile** and source-**upload files**. If you activate the button (...) behind a field, the directory selection dialog opens. For library and configuration files, several paths can be entered for each, separated by semicolons ";".

The information in the **Project** area is stored with the project; information in the **Common** area is written to the ini file of the programming system and thus apply to all projects.

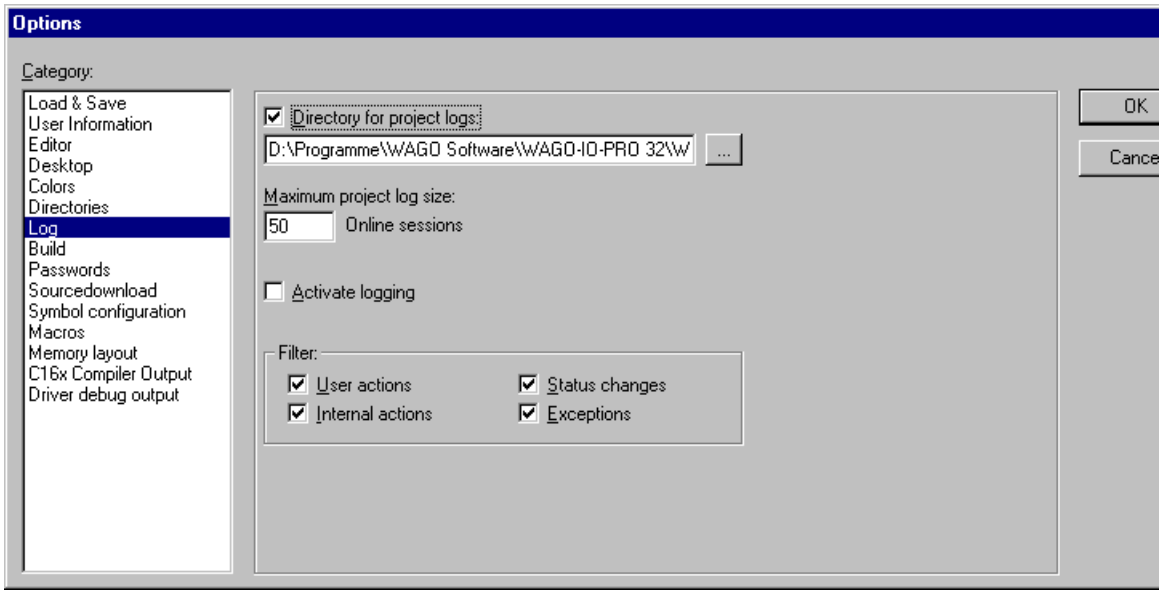
The **Target** area displays the directories for libraries and configuration files set in the target system, e.g. through entries in the Target file. These fields cannot be edited, but an entry can be selected and copied (right mouse button context menu).

WAGO-I/O-*PRO* 32 generally searches first in the directories entered in 'Project', then in those in 'Target System' (defined in the Target file), and finally those listed under 'Common'. If two files with the same name are found, the one in the directory that is searched first will be used.

4.2.8 Options for Log

If you choose this category in the Options dialog box, then you get the following dialog box:

X Option dialogue for the category Log



In this dialog, you can configure a file that acts as a project log, recording all user actions and internal processes during Online mode processing (see also: Log).

If an existing project is opened for which no log has yet been generated, a dialog box opens which calls attention to the fact that a log is now being set up that will receive its first input after the next login process.

The log is automatically stored as a binary file in the project directory when the project is saved. If you prefer a different target directory, you can activate the option **Directory for project logs:** and enter the appropriate path in the edit field. Use the button to access the "Select Directory" dialog for this purpose.

The log file is automatically assigned the name of the project with the extension .log. The maximum number of **Online sessions** to be recorded is determined by **Maximum project log size**. If this number is exceeded while recording, the oldest entry is deleted to make room for the newest.

The Log function can be switched on or off in the Option field **Activate logging**.

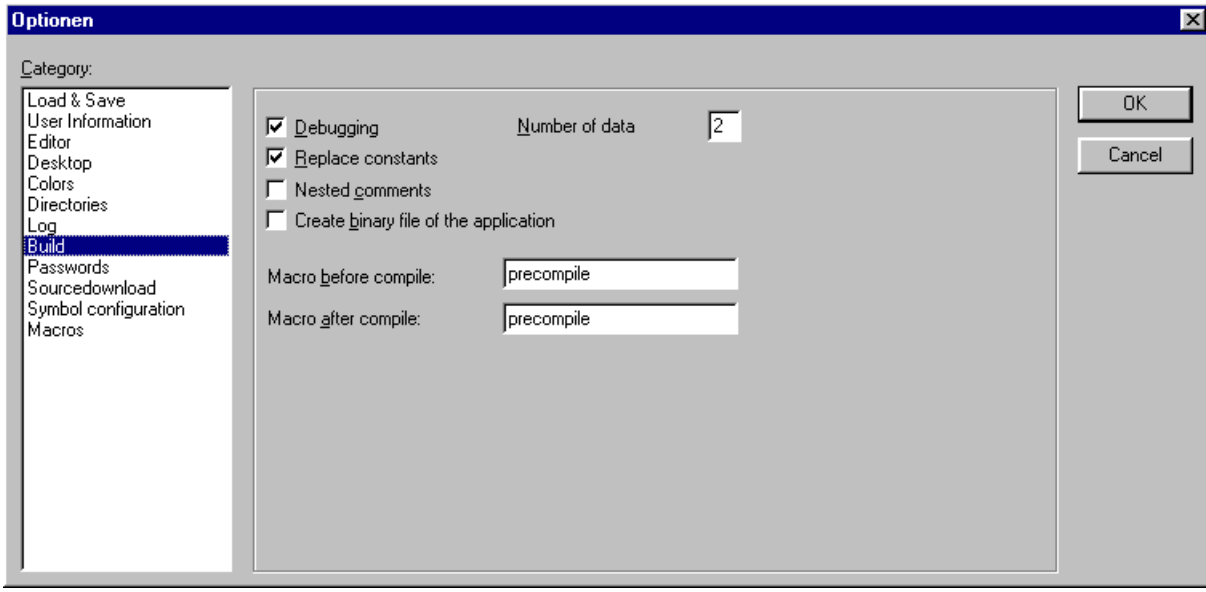
You can select in the **Filter** area which actions are to be recorded: User actions, Internal actions, Status changes, Exceptions. Only actions belonging to categories checked here will appear in the Log window and be written to the Log file. (For a description of the categories, please see Log).

The Log window can be opened with the command 'Window' 'Log'.

4.2.9 Options for Build

If you choose this category in the Options dialog box , then you get the following dialog box:

X Options dialog box of the category Build



When the **Debugging** option is selected, additional debugging code is created, that is the code can become considerably larger. The debugging code is needed in order to make use of the debugging functions offered by **WAGO-I/O-*PRO* 32** (e.g. breakpoints). When you switch off this option, project processing becomes faster and the size of the code decreases. The option is stored with the project.

When the **Replace constants** option is selected, the value of each constant is loaded directly, and in Online mode the constants are displayed in green. Forcing, writing and monitoring of a constant is then no longer possible. If the option is deactivated, the value is loaded into a storage location via variable access (this does in fact allow writing the variable value, but implies longer processing time).

If the **Nested comments** option is active, comments can be placed within other comments. Example:

```
(*

a:=inst.out; (* to be checked *)

b:=b+1;

*)
```

Here, the comment that begins with the first bracket is not closed by the bracket following "checked," but only by the last bracket.

If the option **Create binary file of the application** is activated, a binary image of the generated code (boot project) is created in the project directory during compilation. File name: <project_name>.bin. By comparison, the

command 'Online' 'Create Boot project' sets up the boot project on the controller.

When an option is activated, a check appears next to the option.

By entering a **Number of data** you can determine how many storage segments are to be reserved for your project data in the controller. This space is required so that an Online Change can still be carried out when new variables are added. If during compilation the message "The global variables require too much storage; increase the number you have entered here".

In order to exert control over the compilation process you can set up two macros: the macro in the **Macro before compile** field is executed before the compilation process; the macro in the **Macro after compile** field afterwards. The following macro commands can not, however, be used here: file new, file open, file close, file save as, file quit, online, project compile, project check, project build, debug, watchlist.

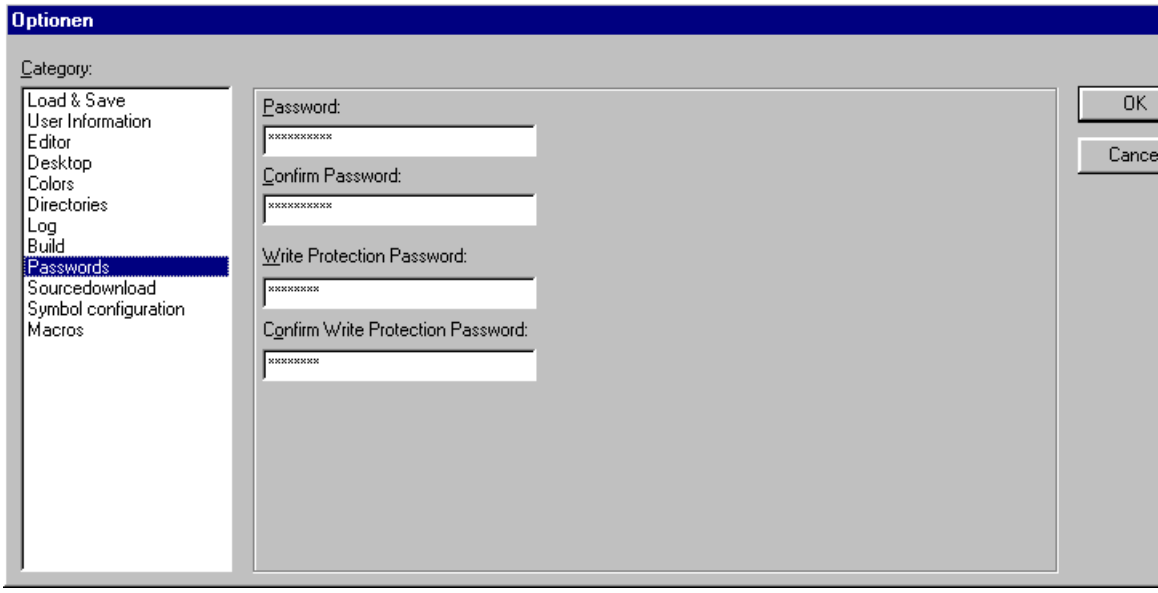
All entries in the Build Options dialog are stored with the project.

When an option is activated, a check appears in front of it.

4.2.10 Passwords

If you choose this category in the Options dialog box, then you get the following dialog box:

X Options dialog box of the category Passwords



To protect your files from unauthorized access **WAGO-I/O-*PRO* 32** offers the option of using a password to protect against your files being opened or changed.

Enter the desired password in the field **Password**. For each typed character an asterisk (*) appears in the field. You must repeat the same word in the field **Confirm Password**. Close the dialog box with **OK**. If you get the message:

"The password does not agree with the confirmation",

then you made a typing error during one of the two entries. In this case repeat both entries until the dialog box closes without a message.

If you now save the file and then reopen it, then you get a dialog box in which you are requested to enter the password. The project can then only be opened if you enter the correct password. Otherwise **WAGO-I/O-*PRO* 32** reports:

"The password is not correct."

Along with the opening of the file, you can also use a password to protect against the file being changed. For this you must enter a password in the field **Write Protection Password** and confirm this entry in the field underneath.

A write-protected project can be opened without a password. For this simply press the button **Cancel**, if **WAGO-I/O-*PRO* 32** tells you to enter the write-protection password when opening a file. Now you can compile the project, load it into the PLC, simulate, etc., but you cannot change it.

Of course it is important that you memorize both passwords. However, if you should ever forget a password, then contact the manufacturer of your PLC.

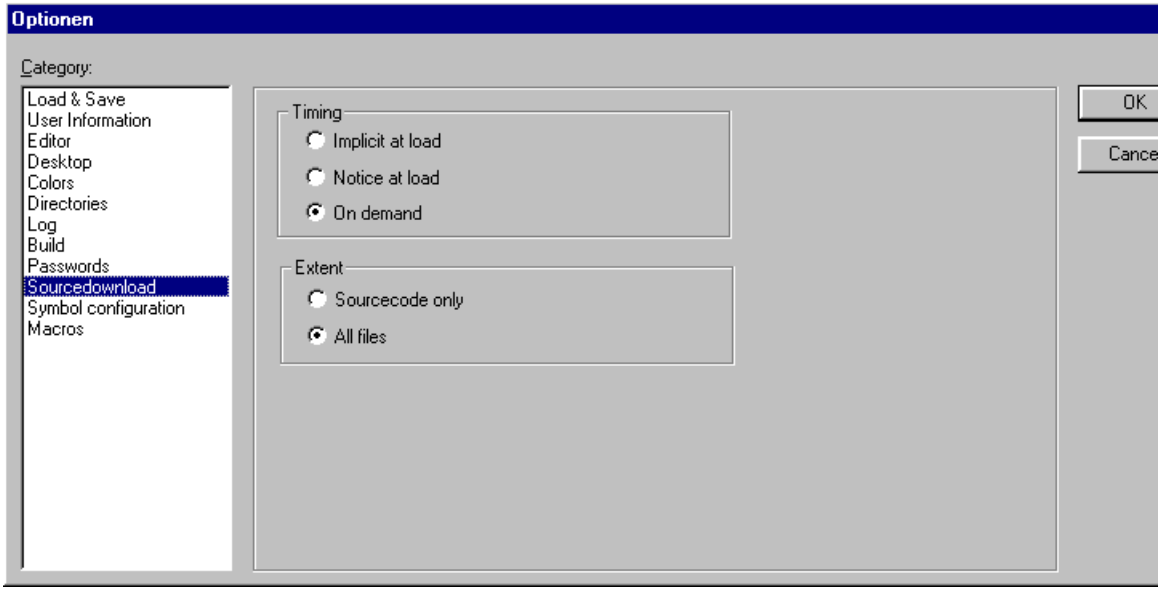
The passwords are saved with the project.

In order to create differentiated access rights you can define user groups and "Passwords for user groups").

4.2.11 'Sourcedownload'

The following dialog will be opened when you select this category:

X Option dialog for the category Sourcedownload



You can choose to which **Timing** and what **Extent** the project is loaded into the controller system. The option **Sourcecode only** exclusively involves just the **WAGO-I/O-*PRO* 32** file (file extension .pro). The option **All files** also includes files such as the associated library files, visualization bitmaps, configuration files, etc.

Using the option **Implicit at load** allows the selected file range to be automatically loaded into the controller system on the command **'Online'** 'Download'.

Using the option **Notice at load** offers a dialog, when the command **'Online'** 'Download' is given, with the question "Do you want to write the source code into the controller system?". Pressing **Yes** will automatically load the selected range of files into the controller system, or you can alternatively finish with **No**.

When using the option **On demand** the selected range of files must be expressly loaded into the controller system by giving the command 'Online' 'Sourcecode download'.

The project which is stored in the controller system can be retrieved by using 'File' 'Open' with Open project from PLC. The files will be unpacked in the process.

4.2.12 Options for 'Symbol Configuration'

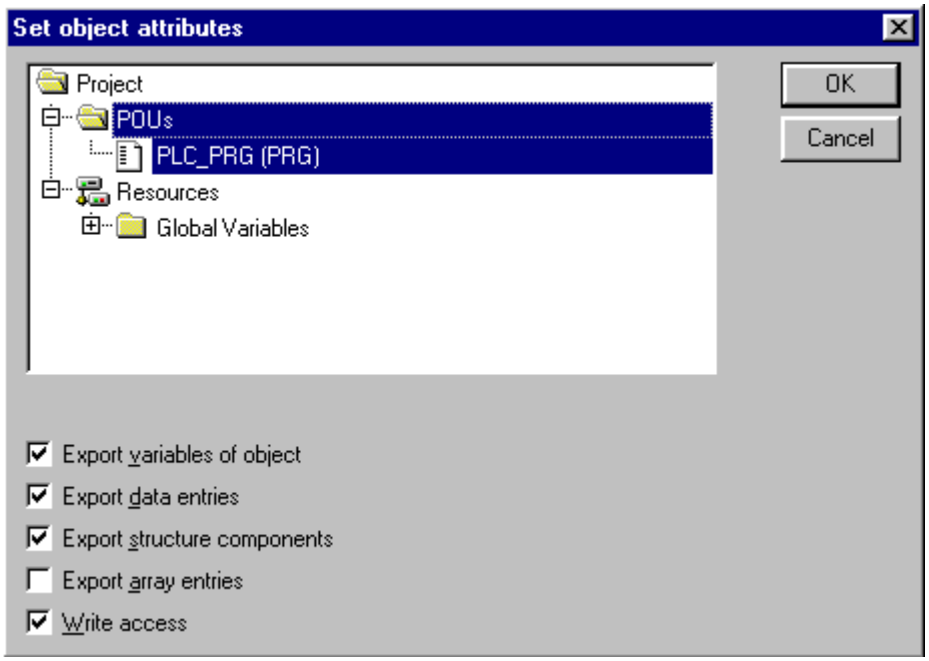
The dialog presented here is used for configuring the symbol file (text file *.sym and binary file *.sdb). These are necessary for data exchange with the controller via the symbol interface and are used for that purpose e.g. by OPC- or GatewayDDE-Server.

If the option **Create symbol entries** is selected, then symbol entries for the project variables are automatically created in the file at each compilation of the project.

Note:
If option 'Symbol config from INI-file' is activated, then the symbol configuration will be read from the WAGO-I/O-PRO 32.ini file or from another ini-file which is defined there. (In this case the dialog 'Set object attributes' in **WAGO-I/O-*PRO* 32** cannot be edited).

If option 'Symbol config from INI-file' is not activated, the symbol entries will be generated in accordance with the settings you can make in the 'Set object attributes' dialog. You get there using the **Configure symbol file** button:

X Set object attributes dialog (in option category Symbol configuration)



Use the tree-structured selection editor to select project POUs and set the desired options in the lower part of the dialog box by clicking the mouse on the corresponding small boxes. Activated options are checked. The following options can be set:

Export variables of object: The variables of the selected object are exported in the symbol file.

The following options can take effect only if the **Export variables of object** option is activated:

Export data entries: Entries for access to the global variables are created for object's structures and arrays.

Export structure components: An individual entry is created for each variable component of object's structures.

Export array entries: An individual entry is created for each variable component of object's arrays.

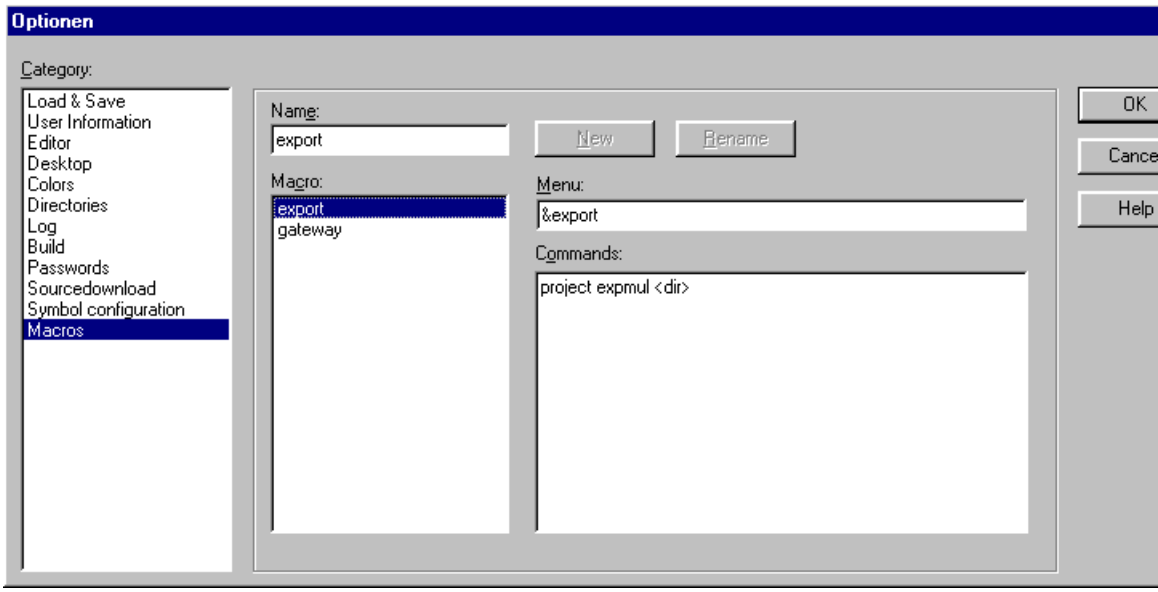
Write Access: Object's variables may be changed by the OPC server.

Once the option settings for the currently selected POU are complete, other POUs can be also be selected and given an option configuration. This can be carried out for any desired number of POU selections, one after the other. When the dialog box is closed by selecting **OK**, all configurations carried out since the dialog box was opened are applied.

4.2.13 Options for 'Macros'

If you choose this category in the Options dialog, the following dialog box opens:

X Options dialog for the category Macros



In this dialog, macros can be defined using the commands of the **WAGO-I/O-*PRO* 32** batch mechanism, which can then be called up in the 'Edit' 'Macros' menu.

In the input field **Name**, you enter a name for the macro to be created. After the **New** button is pressed, this name is transferred into the **Macro** field and marked as selected there. If the focus is on a selected macro, it can be deleted using the <Del> key or given a new name entered in **Name** by pressing the **Rename** button.

In the editor field **Commands** you define and/or edit the commands that are to constitute the newly created or selected macro. All the commands of the **WAGO-I/O-*PRO* 32** batch mechanism are allowed; you can obtain a list by pressing the **Help** button.

A new command line is started by pressing <Ctrl><Enter>. The context menu with the common text editor functions is obtained by pressing the right mouse button. Command components that belong together can be grouped using quotation marks.

The **Menu** field is used to define the menu entry with which the macro will appear in the 'Edit' 'Macros' menu. In order to be able to use a single letter as a short-cut, the letter must be preceded by the symbol '&'. Example: the name "Ma&cro 1" generates the menu entry "Macro 1".

The actual writing of the macros into the project occurs upon leaving the dialog box by selecting **OK**.

The macro menu entries in the 'Edit' 'Macros' menu are displayed in the order in which they were defined.

The macros are first tested when a menu selection is made.

4.3 Managing Projects

The commands which refer to entire project are found under the menu items 'File' and 'Project'.

4.3.1 'File' 'New'

Symbol:

With this command you create an empty project with the name "Untitled". This name must be changed when saving.

4.3.2 'File' 'Open'

Symbol:

With this command you open an already existing project. If a project has already been opened and changed, then **WAGO-I/O-*PRO* 32** asks whether this project should be saved or not.

The dialog box for opening a file appears, and a project file with the extension "*.pro" or a library file with the extension "*.lib" must be chosen. This file must already exist. It is not possible to create a project with the command "Open".

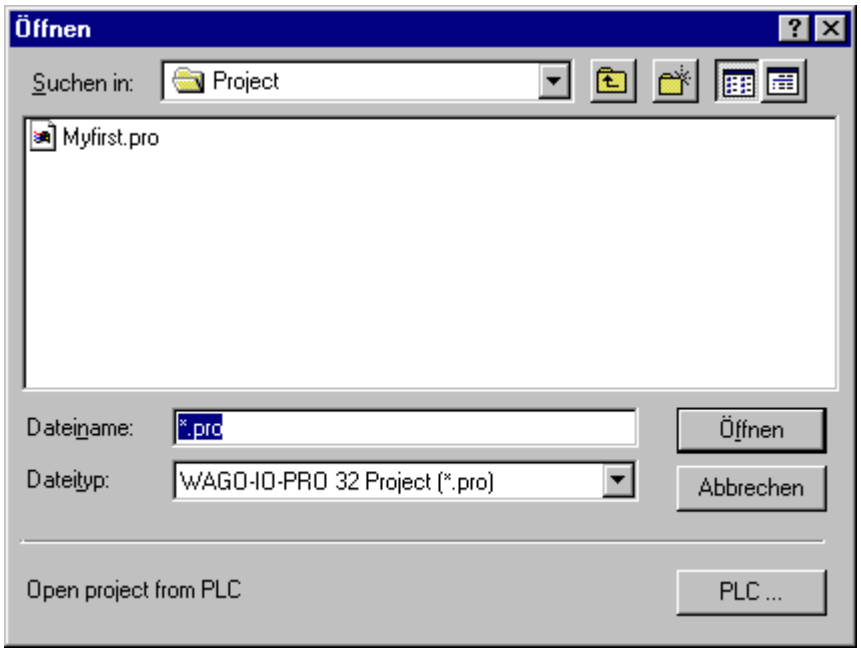
To upload a project file from the PLC, press PLC at Open project from PLC. You will obtain, as next, the dialog Communication parameters (see menu 'Online' 'Communication parameters') for setting the transmission parameters when no connection exists yet to the PLC. Once an on-line connection has been created, the system checks whether the same named project files already exist in the directory on your computer hard disc. When this is the case you receive the dialogue Load the project from the controller where you can decide whether the local files should be replaced by those being used by the controller. (This sequence is the reverse of the sequence of 'Online' 'Load source code', with which the project source file is stored in the controller. Do not confuse with 'Create Boot project'!)

Note:
Please note, that you in any case have to give a new name to a project, when you load it from the PLC to your local directory, otherwise it is unnamed.

If there has not yet been loaded a project to the PLC, you get an error message.

(See also 'Project' 'Options' category 'Sourcedownload').

X Dialog box for opening a file



The most recently opened files are listed under the command 'File' 'Exit'. If you choose one of them, then this project is opened.

If Passwords or User groups have been defined for the project, then a dialog box appears for entering the password.

4.3.3 'File' 'Close'

With this command you close the currently-open project. If the project has been changed, then **WAGO-I/O-*PRO* 32** asks if these changes are to be saved or not.

If the project to be saved carries the name "Untitled", then a name must be given to it (see 'File' 'Save as').

4.3.4 'File' 'Save'

Symbol: **Shortcut: <Ctrl>+<S>**

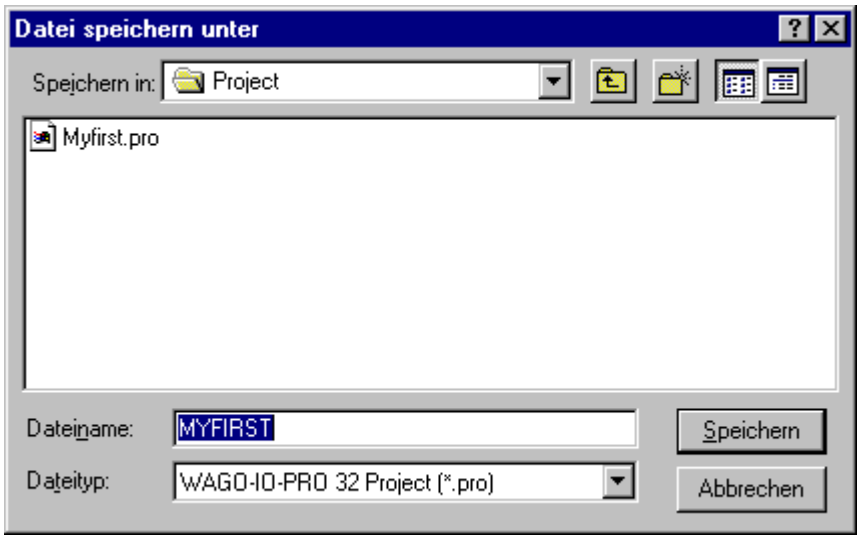
With this command you save any changes in the project. If the project to be saved is called "Untitled", then you must give it a name (see 'File' 'Save as').

4.3.5 'File' 'Save as'

With this command the current project can be saved in another file or as a library. This does not change the original project file.

After the command has been chosen the Save dialog box appears. Choose either an existing **File name** or enter a new file name and choose the desired **file type**.

X Dialog box for Save as



If the project is to be saved under a new name, then choose the file type **WAGO-I/O-*PRO* 32 Project (*.pro)**.

you choose the file type **Project Version 1.5 (*.pro)** or **2.0 (*.pro) or 2.1 (*.pro)**, then the current project is saved as if it were created with the version 1.5 or 2.0 or 2.1 . Specific data of the version 2.2 can thereby be lost! However, the project can be executed with the version 1.5 or 2.0 or 2.1.

You can also save the current project as a library in order to use it in other projects. Choose the file type **Internal library (*.lib)** if you have programmed your POUs in **WAGO-I/O-*PRO* 32**.

Choose the file type **External library (*.lib)** if you want to implement and integrate POUs in other languages (e.g. C). This means that another file is also saved which receives the file name of the library, but with the extension "*.h". This file is constructed as a C header file with the declarations of all POUs, data types, and global variables. If external libraries are used, in the simulation mode the implementation, written for the POUs in **WAGO-I/O-*PRO* 32**, will be executed. Working with he real hardware the implementation written in C will be executed.

Then click **OK**. The current project is saved in the indicated file. If the new file name already exists, then you are asked if you want to overwrite this file.

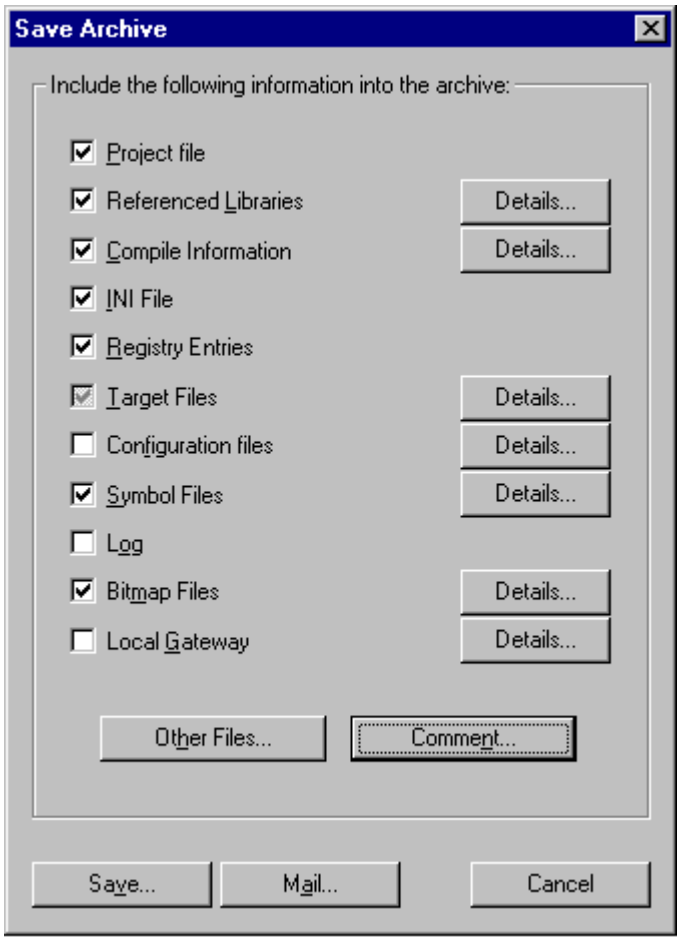
When saving as a library, the entire project is compiled. If an error occurs thereby, then you are told that a correct project is necessary in order to create a library. The project is then not saved as a library.

4.3.6 'File' 'Save/Mail Archive'

This command is used to set up and create a project archive file. All files which are referenced by and used with a **WAGO-I/O-*PRO* 32** project can be packed in a compressed zip file. The zip file can be stored or directly can be sent in an email. This is useful if you want to give forward a set of all project relevant files.

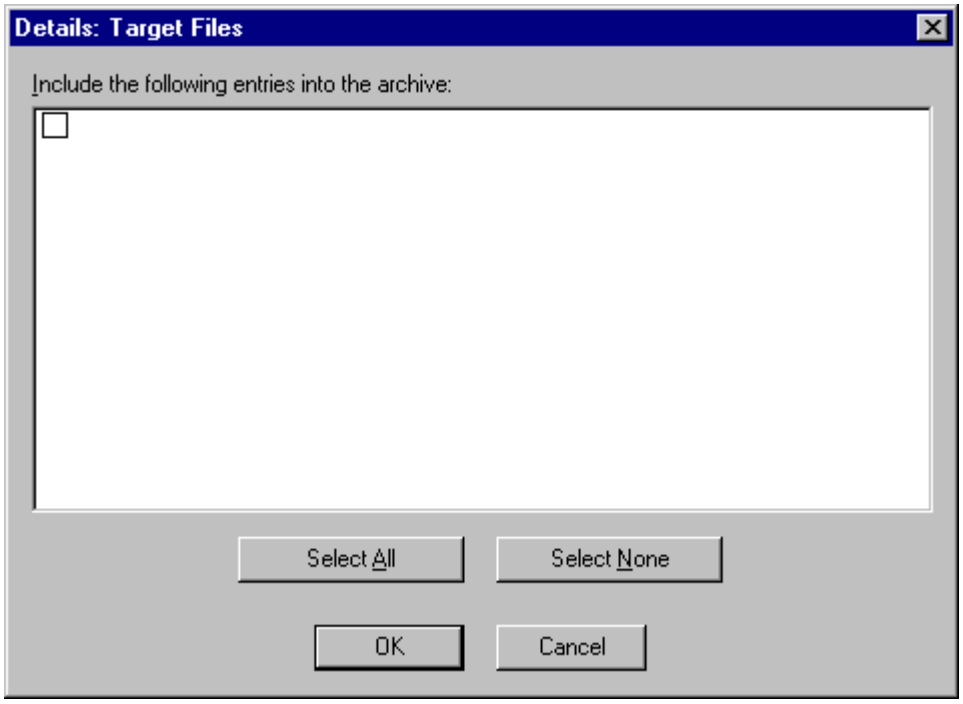
When the command is executed, the dialog box Save Archive opens:

X Dialog box for Setting up an Archive ZIP



Here you can define which file categories should be added to the archive zip file: Select or deselect a category by activating/deactivating the corresponding checkbox. Do this by a single mouseclick in the checkbox or by a doubleclick on the category name. If a category is marked with ☑, all files of this category will be added to the zip file, if it is marked with ☐, none of the files will be added. To select single files of a category press the corresponding button Details. The dialog Details will open with a list of available files.

X Dialog box for detailled selection of files for the Archive ZIP



In this dialog select/deselect the desired files: With the button **Select All** all files of the list are selected, with **Select None** none of them. A single file can be selected/deselected by a mouseclick in the checkbox, also by a doubleclick on the list entry or by pressing the spacebar when the list entry is marked.

Close the Details dialog with **Save** to store the new settings.

In the main dialog the checkbox of categories, for which not all files are selected, will appear with a grey background color .

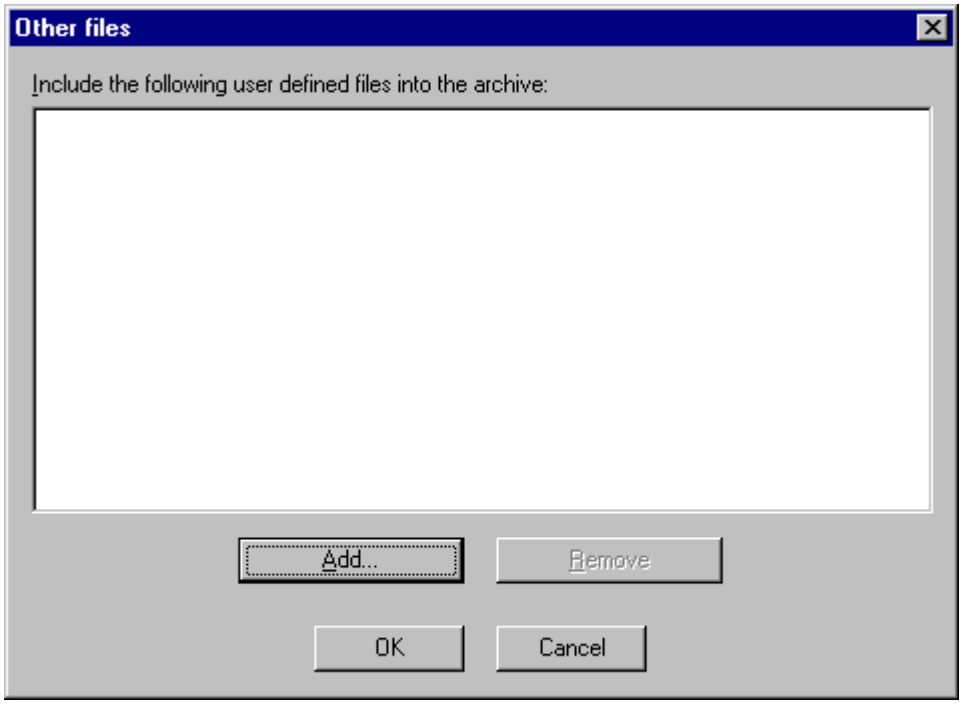
The following file categories are available, the right column of the table shows which files can be added to the zip file:

Project File	projectname.pro (the **WAGO-I/O-*PRO* 32** project file)
Referenced Libraries	*.lib, *.obj, *.hex (libraries and if available the corresponding object and hex-files)
Symbol Files	*.sdb, *.sym (symbolic information)
Compile Information	*.ci (compile information), *.ri (download/reference information) <temp>.* (temporary compile and download files) also for simulation
Log	*.log (project log file)
INI File	WAGO-I/O-PRO 32.ini
Configuration files	files used for PLC configuration (configuration files, device files, icons etc.): e.g. *.cfg, *.con, *.eds, *.dib, *.ico ....

Target Files	*.trg (target files in binary format for all installed targets) *.txt (target files for the installed targets in text format, if available)
Registry Entries	Registry.reg (Entries for Automation Alliance, Gateway und SPS; the following subtrees will be packed: HKEY_LOCAL_MACHINE\SOFTWARE\WAGO-I/O-PRO 32 HKEY_LOCAL_MACHINE\SOFTWARE\AutomationAlliance"
Bitmap Files	*.bmp (bitmaps for project POUs and visualizations)
Gateway Files	Gateway.exe, GatewayDDE.exe, GClient.dll, GDrvBase.dll, GDrvStd.dll, GHandle.dll, GSymbol.dll, GUtil.dll, further DLLs in the gateway directory if available

To add any other files to the zip, press the button **Other Files**. The dialog 'Other files' will open where you can set up a list of desired files.

X Dialog box for adding other files for the Archive ZIP



Press the button Add to open the standard dialog for opening a file, where you can browse for a file. Choose one and confirm with Open. The file will be added to the list in the 'Other files' dialog. Repeat this for each file you want to add. To delete entries from the list, press the button Remove. When the list of selected files is ok, close the dialog with OK.

To add a Readme file to the archive zip, press the button **Comment**. A text editor will open, where you can enter any text. If you close the dialog with OK, during creation of the zip file a **readme.txt** file will be added.

Additionally to the entered comments it will contain information about the build date and version of **WAGO-I/O-*PRO* 32**.

If all desired selections have been made, in the main dialog press

- **Save...** to create and save the archive zip file: The standard dialog for saving a file will open and you can enter the path, where the zip should be stored. The zip file per default is named **<projectname>.zip**. Confirm with **Save** to start building it. During creation the current progress status is displayed and the subsequent steps are listed in the message window.
- **Mail…** to create a temporary archive zip and to automatically generate an empty email which contains the zip as an attachment. This feature only works if the MAPI (Messaging Application Programming Interface) has been installed correctly on the system, otherwise an error message is generated. During setup of the email the progressing status is displayed and the steps of the action are listed in the message window. The temporary zip file will be removed automatically after the action has been finished.
- **Cancel** to cancel the action; no zip file will be generated.

4.3.7 'File' 'Print'

Shortcut: <Ctrl>+<P>

With this command the content of the active window is printed.

After the command has been chosen, then the Print dialog box appears. Choose the desired option or configure the printer and then click OK. The active window is printed. Color output is available from all editors.

X Print dialog box

You can determine the number of the copies and print the version to a file.

With the button Properties you open the dialog box to set up the printer.

You can determine the layout of your printout with the command 'File' 'Printer Setup'.

During printing the dialog box shows you the number of pages already printed. When you close this dialog box, then the printing stops after the next page.

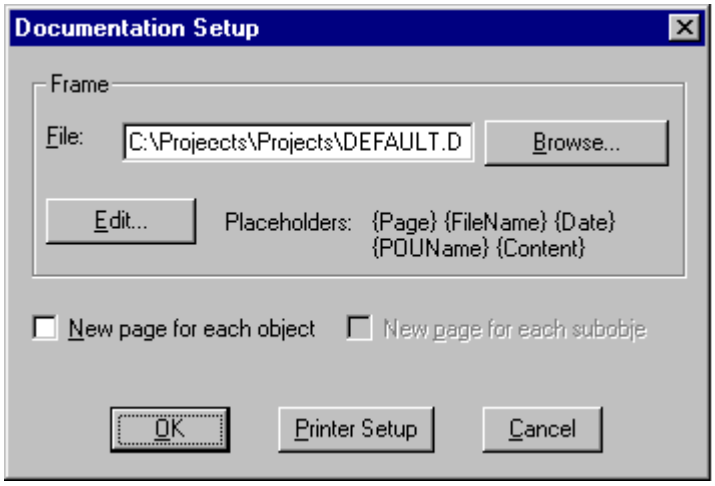
In order to document your entire project, use the command 'Project' 'Document'.

If you want to create a document frame for your project, in which you can store comments regarding all the variables used in the project, then open a global variables list and use the command 'Extras' 'Make docuframe file'.

4.3.8 'File' 'Printer setup'

With this command you can determine the layout of the printed pages. The following dialog box is now opened:

X Page Layout Dialog Box



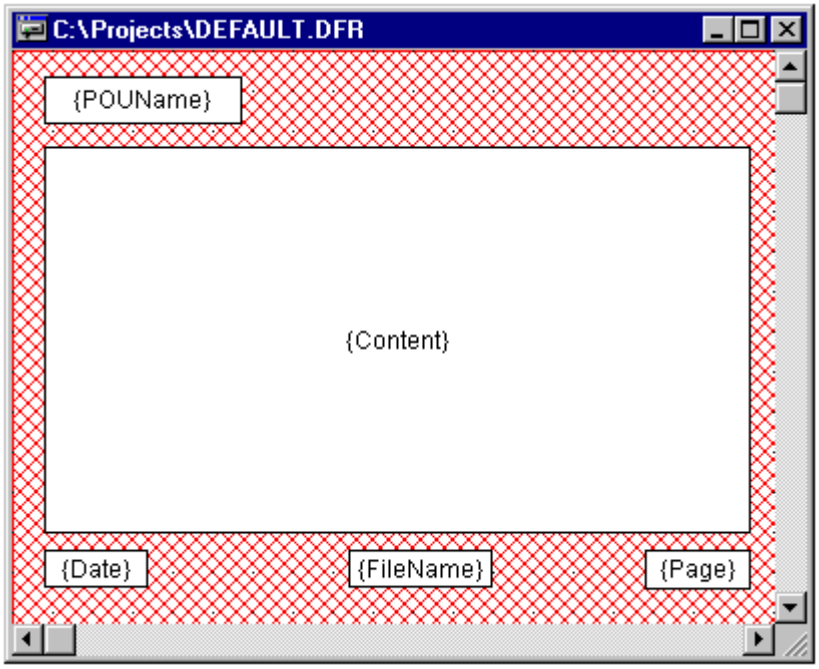
In the field **File** you can enter the name of the file with the extension ".dfr" in which the page layout should be saved. The default destination for the settings is the file DEFAULT.DFR.

If you would like to change an existing layout, then browse through the directory tree to find the desired file with the button **Browse**

You can also choose whether to begin a **new page for each object** and **for each subobject**. Use the **Printer Setup** button to open the printer configuration.

If you click on the **Edit** button, then the frame for setting up the page layout appears. Here you can determine the page numbers, date, filename and POU name, and also place graphics on the page and the text area in which the documentation should be printed.

X Window for pasting the placeholders on the page layout



With the menu item **'Insert' 'Placeholder'** and subsequent selection among the five placeholders (**Page, POU name, File name, Date, and Content**), insert into the layout a so-called placeholder by dragging a rectangle[1] on the layout while pressing the left mouse button. In the printout they are replaced as follows:

Command	Placeholder	Effect
Page	{Page}	Here the current page number appears in the printout.
POU name	{POU Name}	Here the current name of the POU appears.
File name	{File Name}	Here the name of the project appears.
Date	{Date}	Here the current date appears.
Contents	{Contents}	Here the contents of the POU appear.

In addition, with **'Insert' 'Bitmap'** you can insert a bitmap graphic (e.g. a company logo) in the page. After selecting the graphic, a rectangle should also

be drawn here on the layout using the mouse. Other visualization elements can be inserted (see Visualizations).

If the template was changed, then **WAGO-I/O-*PRO* 32** asks when the window is closed if these changes should be saved or not.

4.3.9 'File' 'Exit'

Shortcut: <Alt>+<F4>

With this command you exit from **WAGO-I/O-*PRO* 32**.

If a project is opened, then it is closed as described in 'File' 'Save'.

4.3.10 'Project' 'Build'

Shortcut: <F11>

The project is compiled using 'Project' 'Build'. The compilation process is basically incremental, that is only changed POUs are recompiled. A non-incremental compilation can also be obtained if the command 'Project' 'Clear all' is first executed.

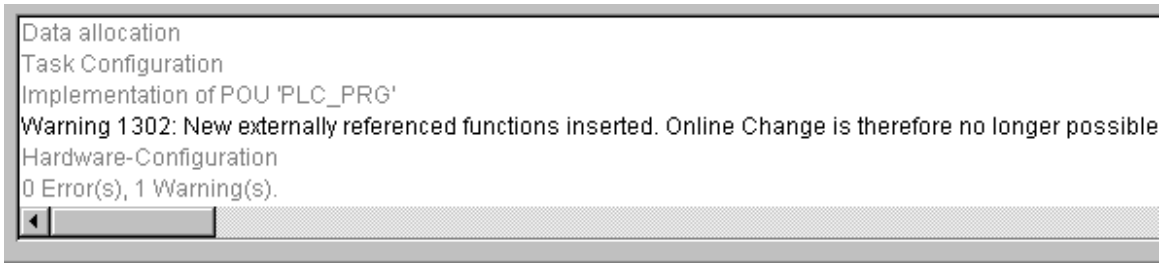
For target systems that support Online Change, all POUs that will be loaded into the controller on the next download are marked with a blue arrow in the Object Organizer after compilation.

The compilation process that is carried out with 'Project' 'Build' occurs automatically if the controller is logged-in via 'Online' 'Log-in'.

During compilation a message window is opened which shows the progress of the compilation process and any errors and warnings which may occur during compilation. Errors and warnings are marked with numbers. Using F1 you get more information about the currently selected error.

See chapter Error Messages and Warnings of the Online Help chapters for a listing of all available error messages and warnings.

X Message window of a project


Data allocation
Task Configuration
Implementation of POU 'PLC_PRG'
Warning 1302: New externally referenced functions inserted. Online Change is therefore no longer possible
Hardware-Configuration
0 Error(s), 1 Warning(s).

If the option Save before compilation is selected in the options dialog of the Load & Save category, the project is stored before compilation.

Note:
Cross references are created during compilation and are stored with the compilation information. In order to be able to use the commands 'Show Call Tree', 'Show Cross Reference' and the commands 'Unused Variables', 'Concurrent Access', and 'Multiple Write Access on output' in the 'Project' 'Check' menu, the project must be rebuilt after any change.

4.3.11 'Project' 'Rebuild all'

With 'Project' 'Rebuild all', unlike the incremental compilation ('Project' 'Build'.Project..Build.>Proc), the project is completely recompiled. Download-Information is not discarded, however, as is the case with the command 'Clear All'.

4.3.12 'Project' 'Clean all'

With this command, all the information from the last download and from the last compilation is deleted.

After the command is selected a dialog box appears, reporting that Login without new download is no longer possible. At this point the command can either be cancelled or confirmed.

Note:
After having done a 'Clean all', a login on the PLC project is only possible if the *.ri file with the project information from the last download was first explicitly saved outside the project directory (see 'Load Download-Information') and can now be reloaded prior to logging-in.

4.3.13 'Project' 'Load Download-Information'

With this command the Download-Information belonging to the project can get reloaded, if it was saved to a directory different from that where the project is. After choosing the command the standard dialogue 'File Open' opens.

The Download-Information is saved automatically at each download to a file, which is named <project name><target identifier>.ri and which is put to the project directory. This file is loaded, when the project is opened and at login it is used to check in which POUs the code has been changed. Only these POUs will be loaded to the PLC during online change procedure.

But: If the *.ri-file in the project directory gets deleted by the command **'Project' 'Clean all'**, you only can reload the Download-Information, if you had stored the *.ri-file in another directory too.

4.3.14 'Project' 'Translate into another language'

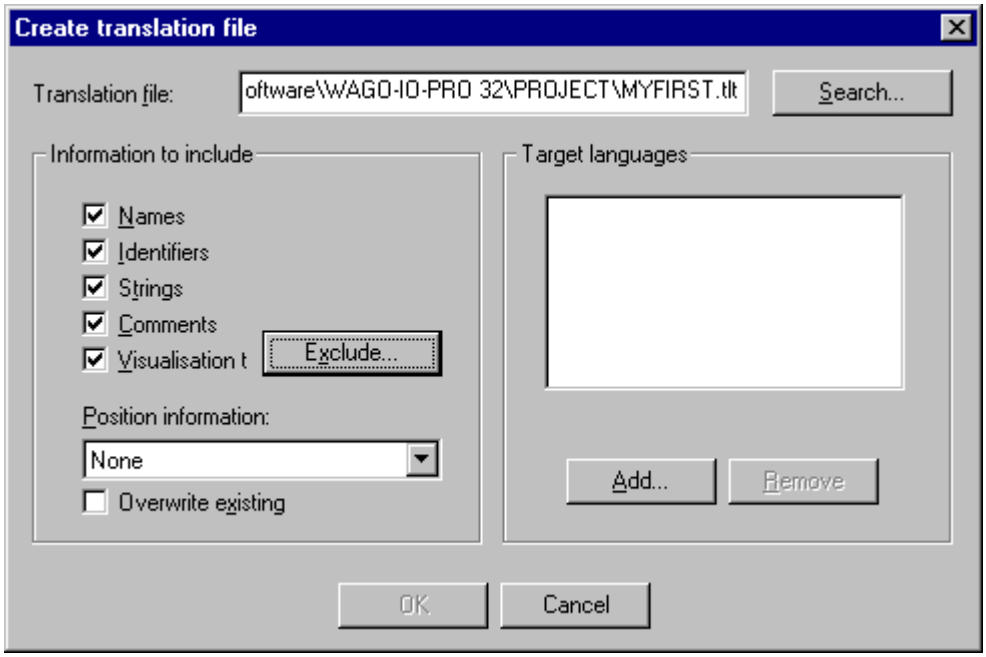
This menu item is used for translating the current project file into another language. This is carried out by reading in a translation file that was generated

from the project and externally enhanced in the desired national language with the help of a text editor.

4.3.14.1 Create translation file

This command in the 'Project' 'Translate into another language' menu leads to the 'Create translation file' dialog.

X Dialog for creating a translation file



In the **Translation file** field, enter a path that shows where the file is to be stored. The default file extension is *.tlt; this is a text file.

If there already exists a translation file which you want to process, give the path of this file or use the **Search** button to reach the standard Windows file selection dialog.

The following information from the project can optionally be passed to the translation file that is being modified or created, so that they will be available for translation: **Names** (names, e.g. the title 'POUs' in Object Organizer), **Identifiers, Strings, Comments, Visualisation texts.** In addition, **Position information** for these project elements can be transferred.

If the corresponding options are checked, the information from the current project will be exported as language symbols into a newly created translation file or added to an already existing one. If the respective option is not selected, information belonging to the pertinent category, regardless of which project it came from, will be deleted from the translation file.

The "Text" and "Tooltip-Text" elements in the visualization elements are considered here to be visualization texts.

Note:
For visualization texts (‚Text' and ‚Text for Tooltip' in the visualization elements) it must be noted that they must be bracketed by two "#" symbols in the configuration dialog of the visualization element (e.g. #text#) in order to be transferred to the translation file. (See in this connection Visualization). These texts are also not translated with the command 'Project' 'Translate into other languages' ! A language change for the visualization can only occur in Online mode if the corresponding language is entered in the 'Extras' 'Settings' dialog.

Position information: This describes with the specifications file path, POU and line the position of the language symbol made available for translation. Three options are available for selection:

'None': No position information is generated.

'First appearance': The position on which the element first appears is added to the translation file.

'All': All positions on which the corresponding element appears are specified.

If a translation file created earlier is to be edited which already contains more position information than that currently selected, it will be correspondingly truncated or deleted, regardless of which project it was generated from.

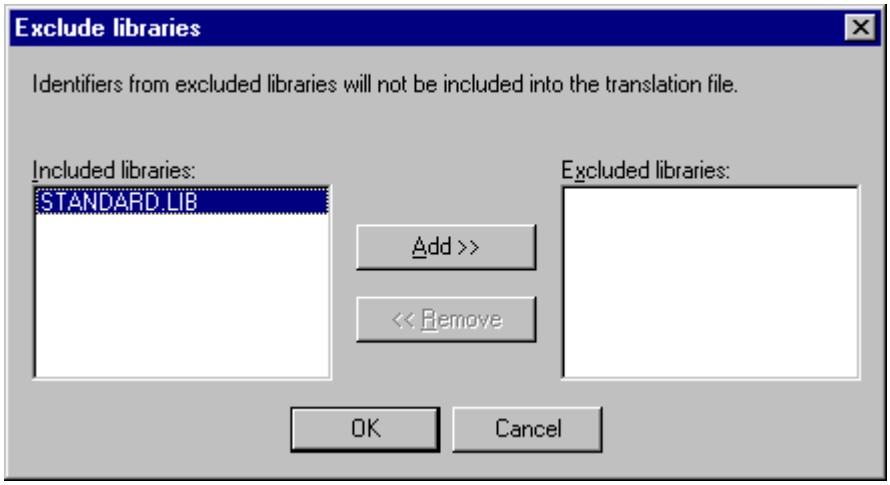
Note:
A maximum of 64 position specifications will be generated per element (language symbol), even if the user has selected "All" under "Position Information" in the ‚Create Translation File' dialog.

Overwrite existing: Existing position information in the translation file, that is currently being processed, will be overwritten, regardless of which project generated it.

Target languages: This list contains identifiers for all languages which are contained in the translation file, as well as those to be added upon completion of the 'Create translation file' dialog.

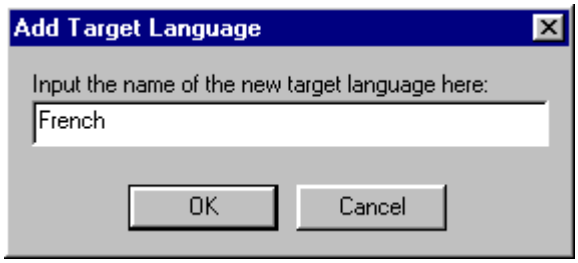
The **Exclude** button opens the 'Exclude libraries' dialog. Here, libraries included to the project can be selected, whose identifier information is not to be transferred to the translation file. To accomplish this, the corresponding entry in the table **Included libraries** on the left is selected with the mouse and placed in the **Excluded libraries** table to the right using the **Add** button. Likewise, entries already placed there can be removed using the **Remove** button. OK confirms the setting and closes the dialog.

X Dialog for excluding library information for the translation file



The **Add** button opens the **'Add Target Language'** dialog:

X Dialog for adding a target language (Project, Translate into Another Language)



A language identifier must be entered into the editor field; it may not have a space or an umlaut character (ä, ö, ü) at either the beginning or the end.

OK closes the 'Add Target Language' dialog and the new target language appears in the target language list.

The **Remove** button removes a selected entry from the list.

You may also confirm the "Create translation file" dialog via **OK**, in order to generate a translation file.

If a translation file of the same name already exists you will get the following confirmation message to be answered Yes or No:

" The specified translation file already exists. It will now be altered and a backup copy of the existing file will be created. Do you want to continue?"

No returns you without action to the 'Create translation file' dialog. If **Yes** is selected, a copy of the existing translation file with the filename "Backup_of_<translation file>.xlt" will be created in the same directory and the corresponding translation file will be modified in accordance with the options that have been entered.

The following takes place when a translation file is generated:

For each new target language, a placeholder ("##TODO") is generated for each language symbol to be displayed.

If an existing translation file is processed, file entries of languages that appear in the translation file, but not in the target language list, are deleted, regardless of the project from which they were generated.

See 'Editing of the translation file' for how to work on the translation file.

4.3.14.2 Editing of the translation file

The translation file must be opened and saved as a text file. The signs ## mark keywords. The ##TODO-placeholders in the file can be replaced by the valid translation. For each language symbol a paragraph is generated which starts with a ##NAME_ITEM and ends with a ##END_NAME_ITEM. (For comments correspondingly ##COMMENT_ITEM etc.).

See in the following an example of a translation file paragraph which handles the name of one of the POUs of the project. ST_Visu. The target languages shall be English(USA) and French. In this examle the position information of the project element which should be translated has been added:

before translation:

```
##NAME_ITEM

[D:\WAGO-I/O-PRO
     32\projects\Bspdt_22.pro::ST_Visualisierung::0]

ST_Visualisierung

##English :: ##TODO

##French :: ##TODO

##END_NAME_ITEM
```

after translation:

The ##TODOs have been replaced by the English resp. French word for 'Visualisierung':

```
##NAME_ITEM

[D:\WAGO-I/O-PRO
     32\projects\Bspdt_22.pro::ST_Visualisierung::0]

ST_Visualisierung

##English :: ST_Visualization

##French :: ST_Visu

##END_NAME_ITEM
```

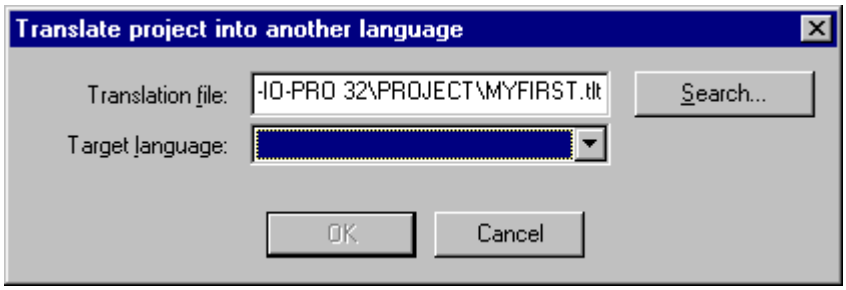
Please check that the translated Identifier and Names remain valid concerning the standard and that strings and comments are in correct brackets.

Note:
The following parts of a translation file should not be modified without detailed knowledge: Language block, Flag block, Position information, Original texts.

4.3.14.3 Translate Project (into another Language)

This command in the 'Project' 'Translate into Another Language' menu opens the 'Translate Project into Another Language' dialog.

X Dialog for translating the project into another language



The current project can be translated into another language if an appropriate translation file is used.

Note:
If you want to save the version of the project in the language in which it was originally created, save a copy of the project prior to translation under a different name. The translation process cannot be undone.

In the field **Translation file**, provide the path to the translation file to be used. By pressing **Search** you may access the standard Windows file selection dialog.

The field **Target language** contains a list of the language identifiers entered in the translation file, from which you can select the desired target language.

OK starts the translation of the current project into the chosen target language with the help of the specified translation file. During translation, a progress dialog is displayed, as well as error messages, if any. After translation, the dialog box and all open editor windows of the project are closed.

Cancel closes the dialog box without modification to the current project.

If the translation file contains erroneous entries, an error message is displayed after OK is pressed, giving the file path and the erroneous line, e.g.: "[C:\Programs\WAGO-I/O-PRO 32\projects\visu.tlt (78)]; Translation text expected"

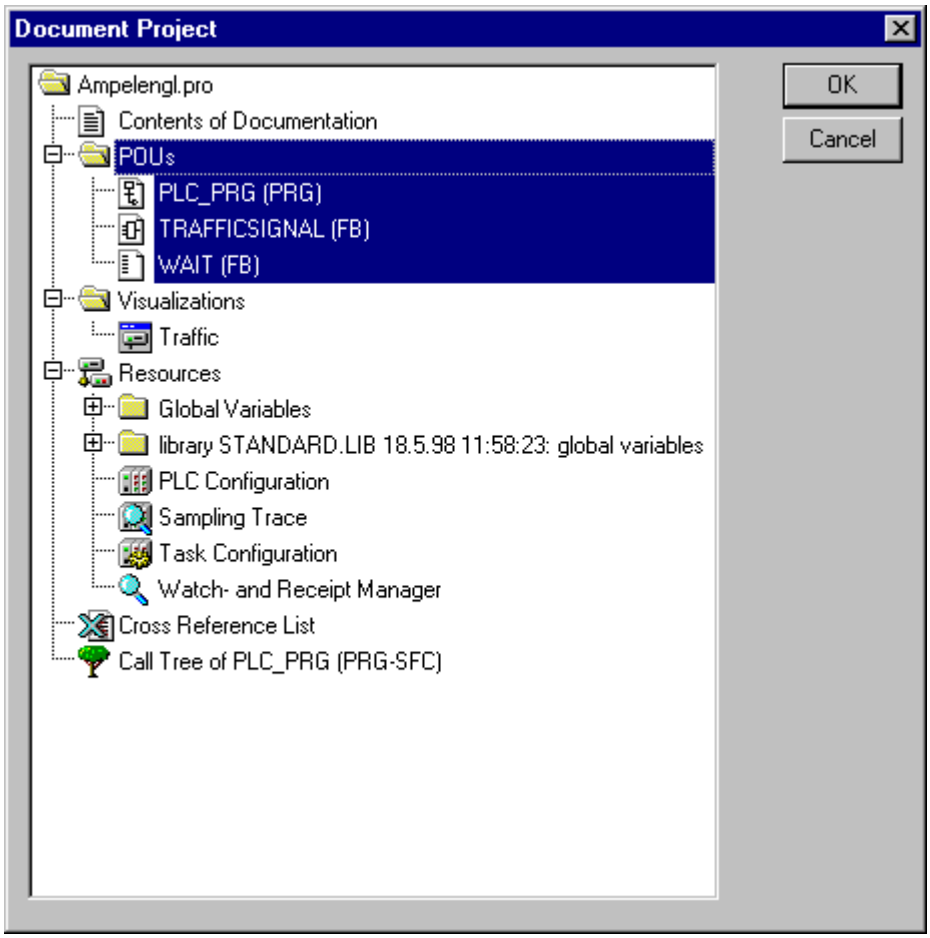
4.3.15 'Project' 'Document'

This command lets you print the documentation of your entire project. The elements of a complete documentation are:

- The POUs,
- the contents of the documentation,
- the data types,
- the visualizations
- the resources ,global variables, variables configuration, the Sampling Trace, the PLC Configuration, the Task Configuration, the Watch and Receipt Manager)
- the call trees of POUs and data types, as well as
- the cross reference list.

For the last two items the project must have been built without errors.

X Dialog box for project documentation



Only those areas in the dialog box are printed which are highlighted in blue.

If you want to select the entire project, then select the name of your project in the first line.

If, on the other hand, you only want to select a single object, then click on the corresponding object or move the dotted rectangle onto the desired object with the arrow key. Objects which have a plus sign in front of their symbols are organization objects which contain other objects. With a click on a plus sign organization object is expanded, and with a click on the resulting minus sign it can be closed up again. When you select an organization object, then all relevant objets are also selected. By pressing the <Shift> key you can select a group of objects, and by pressing the <Ctrl> key you can select several individual objects.

Once you have made your selection, then click on **OK**. The Print dialog box appears. You can determine the layout of the pages to be printed with 'File' 'Printer setup'.

4.3.16 'Project' 'Export'

With **WAGO-I/O-*PRO* 32** projects can be exported or imported. That allows you to exchange programs between different IEC programming systems.

There is a standardized exchange format for POUs in IL, ST, and SFC (the Common Elements format of IEC 1131-3). For the POUs in LD and FBD and the other objects **WAGO-I/O-*PRO* 32** has its own filing format since there is no text format for this in IEC 1131- 3.

The selected objects are written to an ASCII file.

POUs, data types, visualizations, and the resources can be exported. In addition, entries in the library manager, that is the linking information to the libraries, can be exported (not the libraries themselves!).

Note:
Re-importing an exported FBD or LD POU results in an error if a comment in the graphical editor contains a single quotation mark ('), as this will be interpreted as the beginning of a string !

Once you have made your selection in the dialog box window (the same way as with 'Project' 'Document'), you can decide, whether you want to export the selected parts to one file or to export in separate files, one for each object. Switch on or off the option **One file for each object** then click on **OK**. The dialog box for saving files appears. Enter a file name with the expansion ".exp" respectively a directory for the object export files, which then will be saved there with the file name <objectname.exp>.

4.3.17 'Project' 'Import'

In the resulting dialog box for opening files select the desired export file.

The data is imported into the current project. If an object with the same name already exists in the same project, then a dialog box appears with the question "Do you want to replace it?": If you answer **Yes**, then the object in the project

is replaced by the object from the import file. If you answer **No**, then the name of the new objects receives as a supplement an underline and a digit ("_0", "_1", ..). With **Yes, all** or **No, all** this is carried out for all objects.

If the information is imported to link with a library, the library will be loaded and appended to the end of the list in the library manager. If the library was already loaded into the project, it will not be reloaded. If, however, the export file that is being imported shows a different storage time for the library, the library name is marked with a "*" in the library manager (e.g. standard.lib*30.3.99 11:30:14), similar to the loading of a project. If the library can not be found, then an information dialog appears: "Cannot find library {<path>\}<name> <date> <time>", as when a project is loaded.

In the message window the import is registered.

4.3.18 'Project' 'Merge'

With this command you can merge objects (POUs, data types, visualizations, and resources) as well as links to libraries from other projects into your project.

When the command has been given, first the standard dialog box for opening files appears. When you have chosen a file there, a dialog box appears in which you can choose the desired object. The selection takes place as described with 'Project' 'Document' .

If an object with the same name already exists in the project, then the name of the new object receives the addition of an underline and a digit ("_1", "_2" ...).

4.3.19 'Project' 'Compare'

This command is used to compare two projects or to compare the actual version of one project with that which was saved last.

Overview:

In the following the name 'actual project' will be used for the project which is currently under way, the name 'reference project' will be used for that project which has been called to get compared with.

After the command has been executed, the actual project and the reference project will be presented in 'compare mode' in a bipartited window. The names of the POUs, for which differences have been found, are marked by color. For editor POUs also the content of the POUs is displayed in a vis-a-vis way. The results and the way of presenting in compare mode depend on: 1. what filters have been activated for the compare run, affecting the consideration of whitespaces and comments during comparison; 2. whether modification within lines or networks or elements are evaluated as a completely new inserting of a POU or not.

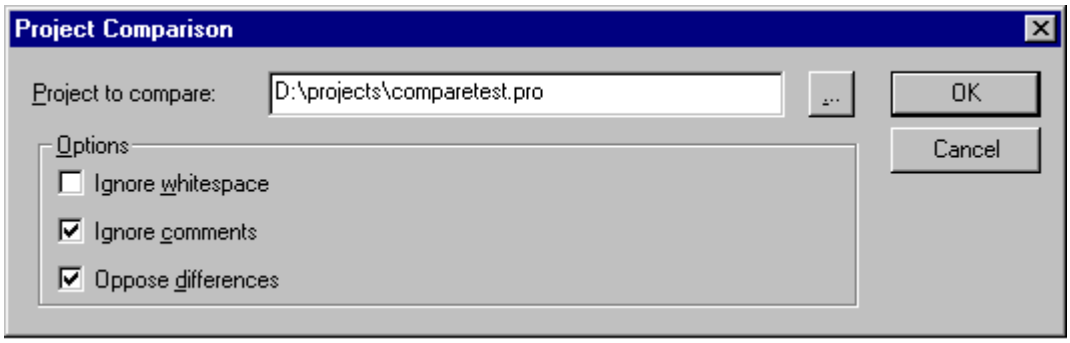
The version of the reference project can be accepted for single diffences or for 'all equally marked' differences. To accept means that the version of the reference project is taken over to the actual project.

Note:
In compare mode (see status bar: COMPARE) the project cannot get edited !

Execute comparison:

After executing the command 'Project' 'Compare' the dialog 'Project Comparison' opens:

X Dialog for Project Comparison



Insert the path of the reference project at **Project to compare**. Press button ... if you want to use the standard dialog for opening a project. If you insert the name of the actual project, the current version of the project will be compared with the version which was saved last.

The following options concerning the comparison can be activated:

Ignore whitespaces: There will be detected no differences which consist in a different number of whitespaces.

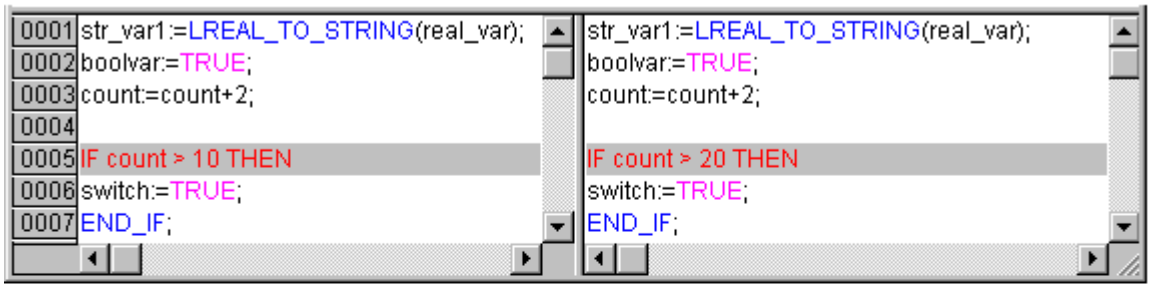
Ignore comments: There will be detected no differences in comments.

Oppose differences: If a line, a network or an element wihthin a POU has been modified, in compare mode it will be displayed in the bipartited window directly opposite to the version of the other project (marked red, see below). If the option is deactivated, the corresponding line will be displayed in the reference project as 'deleted' and in the actual project as 'inserted' (blue/green, see below). This means it will not be displayed directly opposite to the same line in the other project.

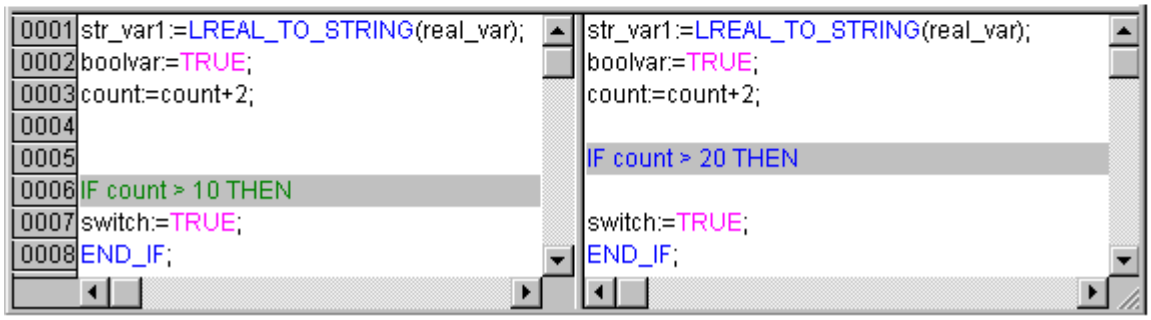
Example:

Line 0005 has been modified in actual project (left side).

Option 'Änderungen gegenüberstellen' aktiviert:



Option 'Änderungen gegenüberstellen' nicht aktiviert:



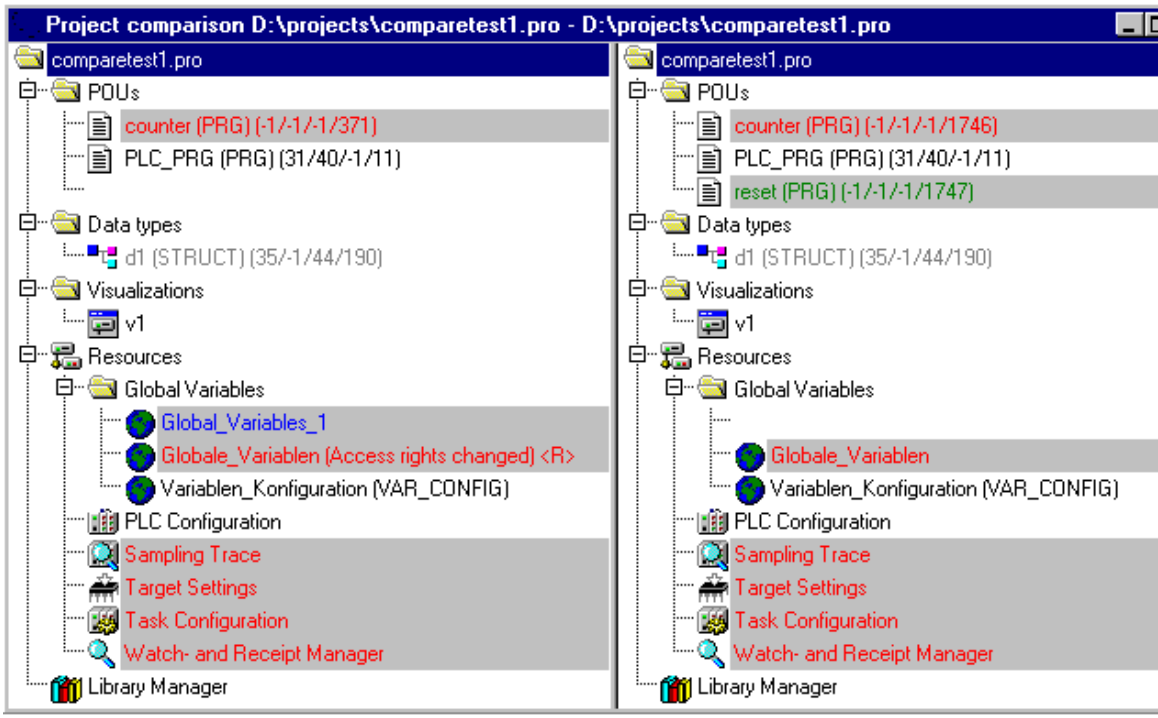
When the dialog Project Comparison is closed by pressing OK, the comparison will be executed according to the settings.

Representation of the comparison result:

Project overview in compare mode:

After the project compare has been executed, a bipartited window opens which shows the project in compare mode. In the title bar you find the project paths: "Project comparison <path of actual project> - <path of reference project>". The actual project is represented In the left half of the window, the reference project in the right one. Each structure tree shows the projects' name at the uppermost position, apart from that it corresponds to the the object organizer structure.

X Example, Project in Compare mode



POUs which are different, are marked in the structure tree by a shadow, a specific color and eventually by an additional text :

Red: Unit has been modified; is displayed with red colored letters in both partitions of the window.

Blue: Unit only available in compare project; a gap will be inserted at the corresponding place in the structure overview of the actual project.

Green: Unit only available in actual project; a gap will be inserted at the corresponding place in the structure overview of the actual project.

Black: Unit for which no differences have been detected.

"(Properties changed)": This text is attached to the POU name in the project structure tree, if differences in the properties of the POU have been detected.

"(Access rights changed)": This text is attached to the POU name in the project structure tree, if differences in the access rights of the POU have been detected.

POU contents in compare mode:

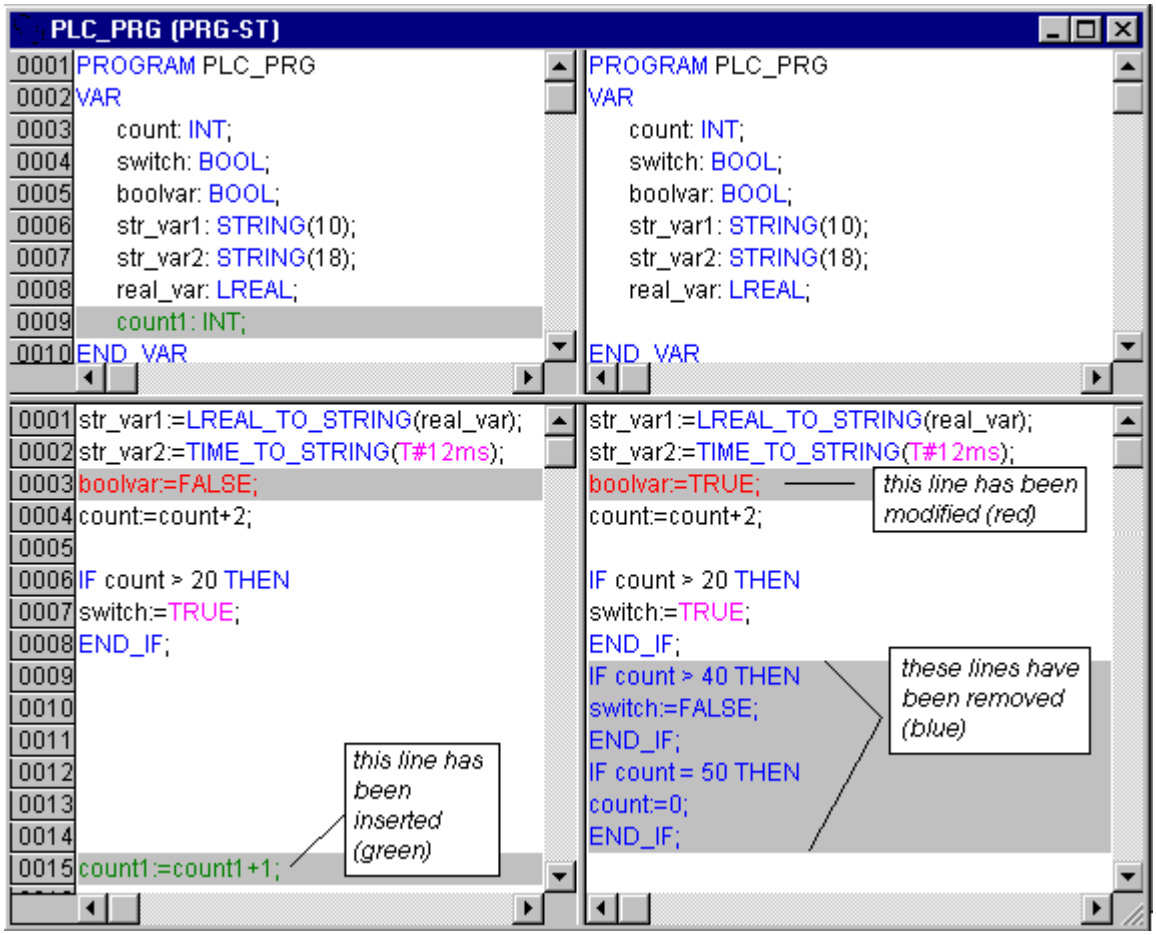
By a double click on a line in the structure overview, which is marked red because of a modification, the POU is opened.

If it is a text or graphic editor POU, it will be opened in a bipartited window. The content of the reference project (right side) is set opposite to that of the actual project (left side). The smallest unit which will be regarded during

comparison, is a line (declaration editor, ST, IL), a network (FBD, LD) or an element (CFC, SFC). The same coloring will be used as described above for the project overview.

Example:

X Example, POU in compare mode



If it is not a editor POU, but the task configuration, the target settings etc., then the POU version of the actual and the reference project can be opened in separate windows by a double click on the respective line in the project structure. For those project POUs no further details of differences will be displayed.

Working in the compare mode (Menu 'Extras', Context menu):

If the cursor is placed on a line in the bipartited window, which indicates a difference, the menu 'Extras' resp. The context menu offers a selection of the following commands, depending on whether working in the project overview or in a POU.

4.3.19.1 'Extras' 'Next difference'

The cursor jumps to the next unit, where a difference is indicated. (line in project overview, line/network/element in POU)

4.3.19.2 'Extras' 'Previous difference'

The cursor jumps to the previous unit, where a difference is indicated . (line in project overview, line/network/element in POU)

4.3.19.3 'Extras' 'Accept change'

For all coherent (e.g. subsequent lines) units, which have the same sort of difference marking, the version of the reference project will be accepted for the actual project. The corresponding units will be shown (with the corresponding coloring) in the left side of the window. If it is an unit, which is marked red (just modification), then the acceptance will be recognizable by yellow coloring of the text in the actual project.

4.3.19.4 'Extras' 'Accept changed item'

Only the single unit (line, network, element) where the cursor is currently placed, will be accepted for the actual version. The corresponding units will be shown (with the corresponding coloring) in the left side of the window. If it is an unit, which is marked red (just modification), then the acceptance will be recognizable by yellow coloring of the text in the actual project.

4.3.19.5 'Extras' 'Accept properties'

The object properties for the POU, where the cursor is currently placed, will be accepted for the actual project as they are set in the reference version.

4.3.19.6 'Extras' 'Accept access rights'

(only in project overview): The object access rights for the POU, where the cursor is currently placed, will be accepted for the actual project as they are set in the reference version .

4.3.20 'Project' 'Project info'

Under this menu item the information about your project can be saved. When the command has been given, then the following dialog box opens:

X Dialog box for entering project information

The following project information is displayed:

- **File** name
- Directory path
- The time of the most recent change (**Change date**)

This information can not be changed.

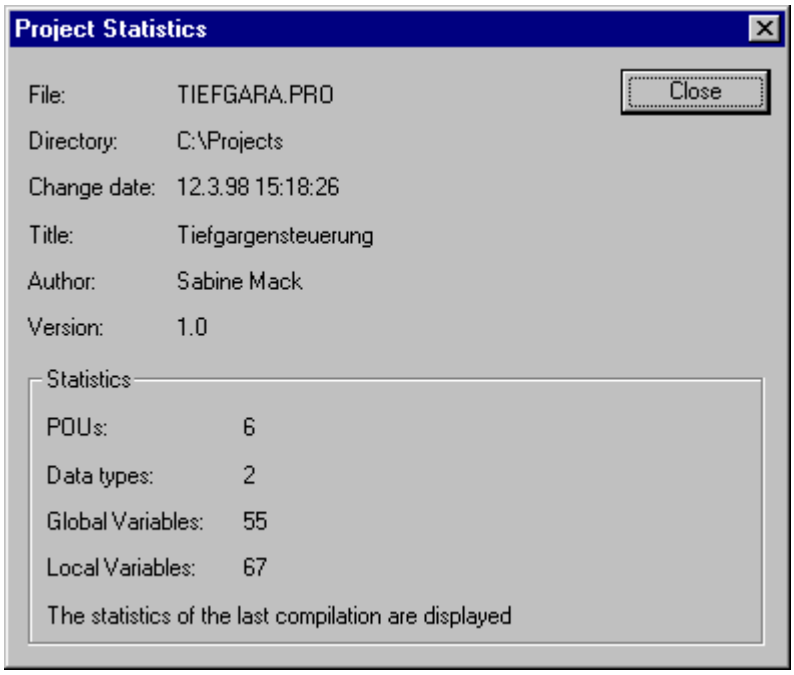
In addition, you can can add the following information:

- A **Title** of the project,
- the name of the **Author**,
- the **Version** number, and
- a **Description** of the project.

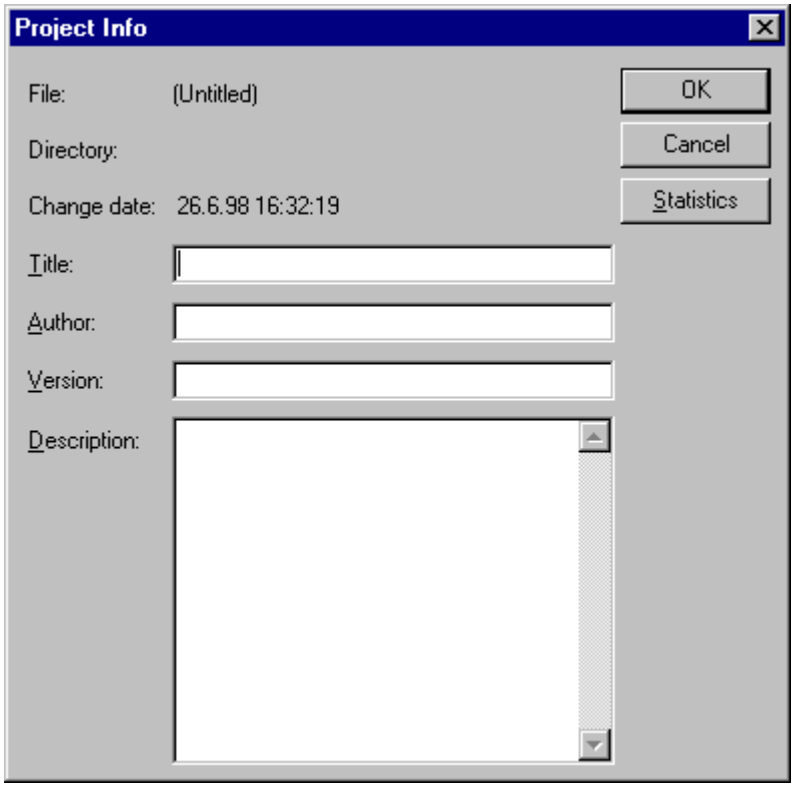
This information is optional. When you press the button **Statistics** you receive statistical information about the project.

It contains information such as the number of the POUs, data types, and the local and global variables as they were traced at the last compilation.

X Example of project statistics



If you choose the option **Ask for project info** in the category **Load & Save** in the Options dialog box, then while saving a new project, or while saving a project under a new name, the project info is called automatically.



4.3.21 'Project' 'Global Search'

With this command you can search for the location of a text in POUs, data types, or in the objects of the global variables.

When the command is entered, a dialog box opens in which you can choose the desired object. The selection is made as in the 'Project' 'Document' description.

If the selection is confirmed with **OK**, the standard dialog for Search will be opened. This appears immediately when the command 'Global Search' is invoked via the symbol in the menu bar; the search is then automatically carried out in all searchable parts of the project. The most recently entered search strings can be selected through the combo box of the **Search for** field. If a text string is found in an object, the object is loaded into the corresponding editor or in the library manager and the location where the string was found is displayed. The display of the text that is found, as well as the search and find next functions behave similarly to the command 'Edit' 'Search'.

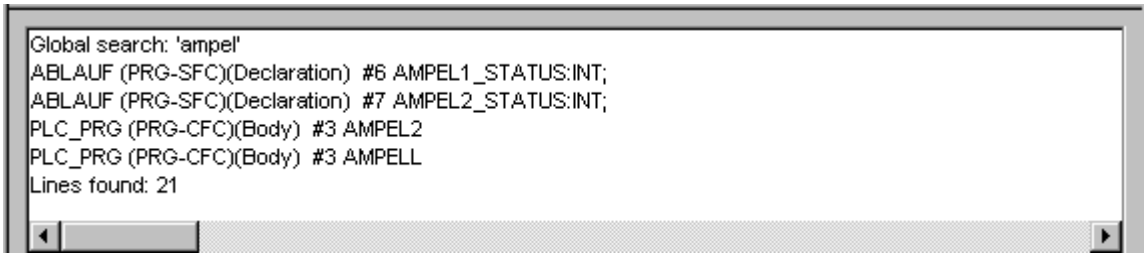
If you select the **In message window** button, all locations where the series of symbols searched for appears in the selected object will be listed line by line in tabular form in the message window. Afterward, the number of locations found will be displayed.

If the report window was not opened, it will be displayed. For each location that is found, the following will be displayed:

- Object name

- Location of the find in the Declaration (Decl) or in the Implementation (Impl) portion of a POU
- Line and network number if any
- The full line in the text editors
- Complete text element in the graphic editors

X Message window with search result display



If you double-click the mouse on a line in the message window or press <Enter>, the editor opens with the object loaded. The line concerned in the object is marked. You can jump rapidly between display lines using the function keys <F4> and <Shift>+<F4>.

4.3.22 'Project' 'Global replace'

With this command you can search for the location of a text in POUs, data types, or the objects of the global variables and replace this text by another. This is executed in the same way as with 'Project' 'Global Search' or 'Edit' 'Replace'. The libraries, however, are not offered for selection and no display in the message window is possible.

Results are displayed in the message window.

4.3.23 'Project' 'Check'

Each of these functions tests the state of the most recent compilation. The project must therefore have been compiled error-free at least once, before the test can be carried out; if not, the menu items are "greyed out".

4.3.23.1 Unused Variables

This function in the 'Project' 'Check' menu searches for variables that have been declared but not used in the program. They are outputted by POU name and line, e.g.: PLC_PRG (4) – var1. Variables in libraries are not examined.

Results are displayed in the message window.

4.3.23.2 Overlapping memory areas

This function in the 'Project' 'Check' menu tests whether in allocation of variables via the "AT" declaration overlaps have arisen at specific memory areas. For example, an overlap occurs when allocating the variables "var1 AT %QB21: INT" and "var2 AT %QD5: DWORD" because they both use byte 21. The output then appears as follows:

%QB21 is referenced by the following variables:

```
PLC_PRG (3): var1 AT %QB21

PLC_PRG (7): var2 AT %QD5
```

Results are displayed in the message window.

4.3.23.3 Access conflict

This function in the 'Project' 'Check' menu searches for memory areas which are referenced in more than one task. No distinction is made here between read and write access. The output is for example:

%MB28 is referenced in the following tasks:

```
Task1 - PLC_PRG (6): %MB28 [read-only access]

Task2 - POU1.ACTION (1) %MB28 [write access]
```

Results are displayed in the message window.

4.3.23.4 Multiple writes to output

This function of the 'Project' 'Check' menu searches for memory areas to which a single project gains write access at more than one place. The output then appears as follows:

%QB24 is written to at the following locations:

```
PLC_PRG (3): %QB24

PLC_PRG.POU1 (8): %QB24
```

Results are displayed in the message window.

4.3.23.5 User groups

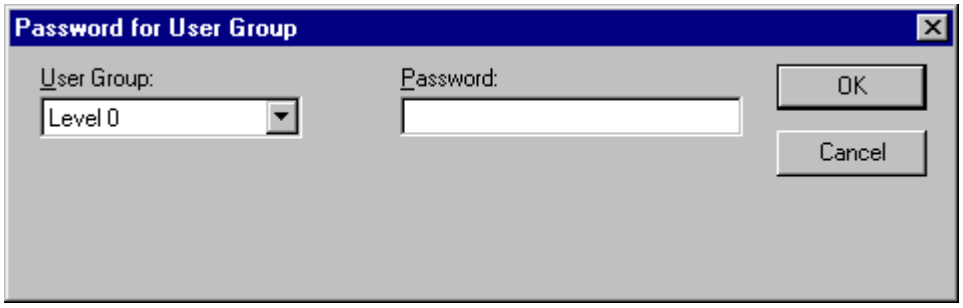
In **WAGO-I/O-*PRO* 32** up to eight user groups with different access rights to the POUs, data types, visualizations, and resources can be set up. Access rights for single objects or all of them can be established. Only a member of a certain user group can open a project. A member of such a user group must identify himself by means of a password.

The user groups are numbered from 0 to 7, whereby the Group 0 has the administrator rights, i.e. only members of group 0 may determine passwords and access rights for all groups and/or objects.

When a new project is launched, then all passwords are initially empty. Until a password has been set for the 0 group, one enters the project automatically as a member of the 0 group.

If a password for the user group 0 is existing while the project is loaded, then a password will be demanded *for all* groups when the project is opened. For this the following dialog box appears:

X Dialog box for password entry



In the combobox **User group** on the left side of the dialog box, enter the group to which you belong and enter on the right side the relevant **password**. Press **OK**. If the password does not agree with the saved password, then the message appears:

"The password is not correct."

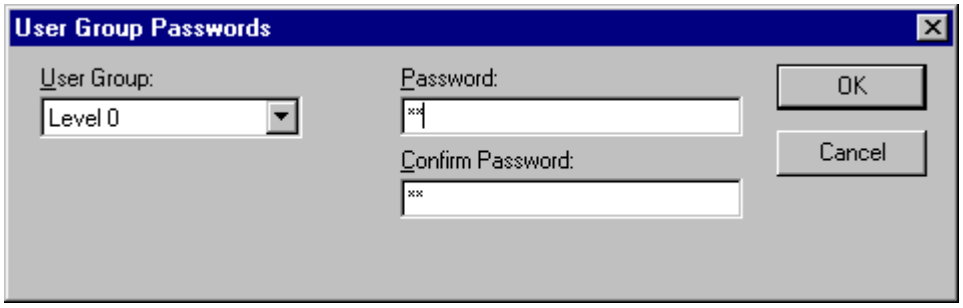
Only when you have entered the correct password the project can be opened.

With the command 'Passwords for user group' you can assign the passwords, and with 'Object' 'Access rights' you can define the rights for single objects or for all of them.

4.3.24 'Project' 'Passwords for user groups'

With this command you open the dialog box for password assignment for user groups. This command can only be executed by members of group 0. When the command has been given, then the following dialog box appears:

X Dialog box for password assignment



In the left combobox **User group** you can select the group. Enter the desired password for the group in the field **Password**. For each typed character an asterisk (*) appears in the field. You must repeat the same password in the field **Confirm password**. Close the dialog box after each password entry with **OK**. If you get the message:

"The password does not agree with the confirmation",

then you made a typing error during one of the two entries. In this case repeat both entries until the dialog box closes without a message.

Then, if necessary, assign a password for the next group by calling the command again.

Note:
If passwords are not assigned to all user groups, a project can be opened by way of a group to which no password was assigned!

Use the command 'Object' 'Access rights' to assign the rights for single objects or all of them.

4.4 Managing Objects in a Project

Now we shall explain how to work with objects and what help is available to keep track of a project (Folders, Call tree, Cross reference list,..).

4.4.1 Object

POUs, data types, visualizations and the resources global variables, the variable configuration, the Sampling Trace, the PLC Configuration, the Task Configuration, and the Watch and Receipt Manager are all defined as "objects". The folders inserted for structuring the project are partially involved. All objects of a project are in the Object Organizer.

If you hold the mouse pointer for a short time on a POU in the Object Organizer, then the type of the POU (Program, Function or Function block) is shown in a Tooltip. For the global variables the tooltip shows the keyword (VAR_GLOBAL, VAR_CONFIG).

With drag & drop you can shift objects (and also folders, see 'Folder') within an object type. For this, select the object and shift it to the desired spot by holding down the left mouse button. If the shift results in a name collision, the newly introduced element will be uniquely identified by an appended, serial number (e.g. "Object_1").

4.4.2 Folder

In order to keep track of larger projects you should group your POUs, data types, visualizations, and global variables systematically in folders.

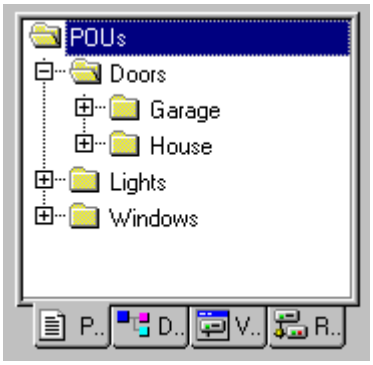
You can set up as many levels of folders as you want. If a plus sign is in front of a closed folder symbol , then this folder contains objects and/or additional folders. With a click on the plus sign the folder is opened and the subordinated objects appear. With a click on the minus (which has replaced the plus sign) the folder can be closed again. In the context menu you find the commands 'Expand nodes' and 'Collapse nodes' with the same functions.

With Drag&Drop you can move the objects as well as the folders within their object type. For this select the object and drag it with pressed left mouse button to the desired position.

You can create more folders with the command 'New folder'.

Note:
Folders have no influence on the program, but rather serve only to structure your project clearly.

X Example of folders in the Object Organizer



4.4.3 'New Folder'

With this command a new folder is inserted as a structural object. If a folder has been selected, then the new one is created underneath it. Otherwise it is created on the same level. If an action is selected, the new folder will be inserted at the level of the POU to which the action belongs.

The context menu of the Object Organizer which contains this command appears when an object or the object type has been selected and you have pressed the right mouse button or <Shift>+<F10>.

The newly inserted folder initially has the designation 'New Folder'. Observe the following naming convention for folders:

- Folders at the same level in the hierarchy must have distinct names. Folders on different levels can have the same name.
- A folder can not have the same name as an object located on the same level.

If there is already a folder with the name "New Folder" on the same level, each additional one with this name automatically receives an appended, serial number (e.g. "New Folder 1"). Renaming to a name that is already in use is not possible.

4.4.4 'Expand nodes' 'Collapse nodes'

With the command expand the objects are visibly unfolded which are located in the selected object. With Collapse the subordinated objects are no longer shown.

With folders you can open or close them with a double mouse click or by pressing **<Enter>**.

The context menu of the Object Organizer which contains this command appears when an object or the object type has been selected and you have pressed the right mouse button or **<Shift>+<F10>**.

4.4.5 'Project' 'Object Delete'

Shortcut: <Delete>

With this command the currently selected object (a POU, a data type, a visualization, or global variables), or a folder with the subordinated objects is removed from the Object Organizer and is thus deleted from the project

For safety you are asked once more for confirmation.

If the editor window of the object was open, then it is automatically closed.

If you delete with the command 'Edit' 'Cut', then the object is parked on the clipboard.

4.4.6 'Project' 'Object Add'

Shortcut: <Insert>

With this command you create a new object. The type of the object (POU, data type, visualization, or global variables) depends upon the selected register card in the Object Organizer. Enter the Name of the new POU in the dialog box which appears. Remember that the name of the object may not have already been used.

Take note of the following restrictions:

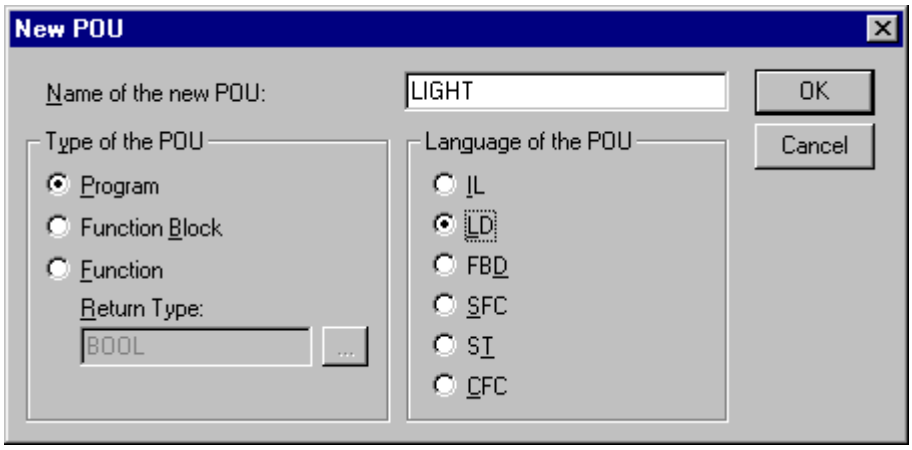
- The name of a POU can not include any spaces
- A POU can not have the same name as another POU, or a data type.
- A data type can not receive the same name as another data type or a POU.
- A global variable list can not have the same name as another global variable list.
- An action can not have the same name as another action in the same POU.
- A visualization can not have the same name as another visualization.

In all other cases, identical naming is allowed. Thus for example actions belonging to different POUs can have the same name, and a visualization may have the same as a POU.

In the case of a POU, the POU type (program, function or function block) and the language in which it is programmed must also be selected. 'Program' is the default value of **Type of the POU**, while that of **Language of the POU** is that of most recently created POU. If a POU of the function type is created, the desired data type must be entered in the **Return Type** text input field. Here all

elementary and defined data types (arrays, structures, enumerations, aliases) are allowed. Input assistance (e.g. via <F2>) can be used.

X Dialog for creating a new POU



After pressing **OK**, which is only possible if there is no conflict with the naming conventions described above, the new object is set up in the Object Organizer and the appropriate input window appears.

If the command **'Edit' 'Insert'** is used, the object currently in the clipboard is inserted and no dialog appears. If the name of the inserted object conflicts with the naming conventions (see above), it is made unique by the addition of a serial number appended with a leading underline character (e.g. "Rightturnsig_1").

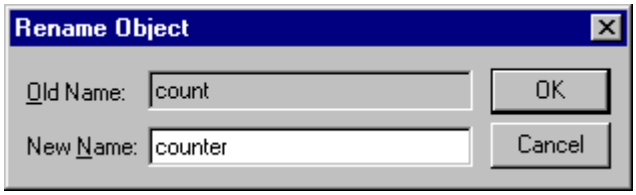
4.4.7 'Project' 'Object Rename'

Shortcut: <Spacebar>

With this command you give a new name to the currently-selected object or folder. Remember that the name of the object may not have already been used.

If the editing window of the object is open, then its title is changed automatically when the name is changed.

X Dialog box for renaming a POU



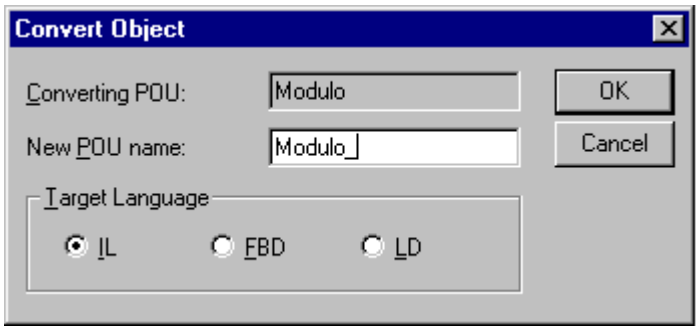
4.4.8 'Project' 'Object Convert'

This command can only be used with POUs. You can convert POUs from the languages SFC, ST, FBD, LD, and IL into one of the three languages IL, FBD, and LD.

For this the project must be compiled. Choose the language into which you want to convert and give the POU a new name. Remember that the name of the POU may not have already been used. Then press **OK**, and the new POU is added to your POU list.

The type of processing that occurs during conversion corresponds to that which applies to compilation.

X Dialog box for converting a POU

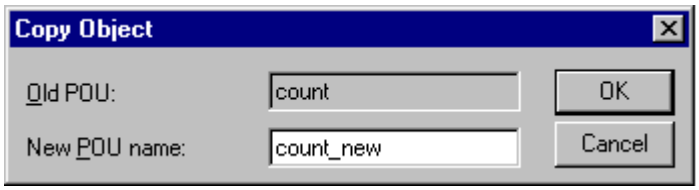


4.4.9 'Project' 'Object Copy'

With this command a selected object is copied and saved under a new name. Enter the name of the new object in the resulting dialog box. Remember that the name of the object may not have already been used.

If, on the other hand, you used the command **'Edit' 'Copy'**, then the object is parked on the clipboard, and no dialog box appears.

X Dialog box for copying a POU



4.4.10 'Project' 'Object Open'

Shortcut: <Enter>

With the command you load a selected object within the Object Organizer into the respective editor. If a window with this object is already open, then it gets a focus, is moved into the foreground and can now be edited.

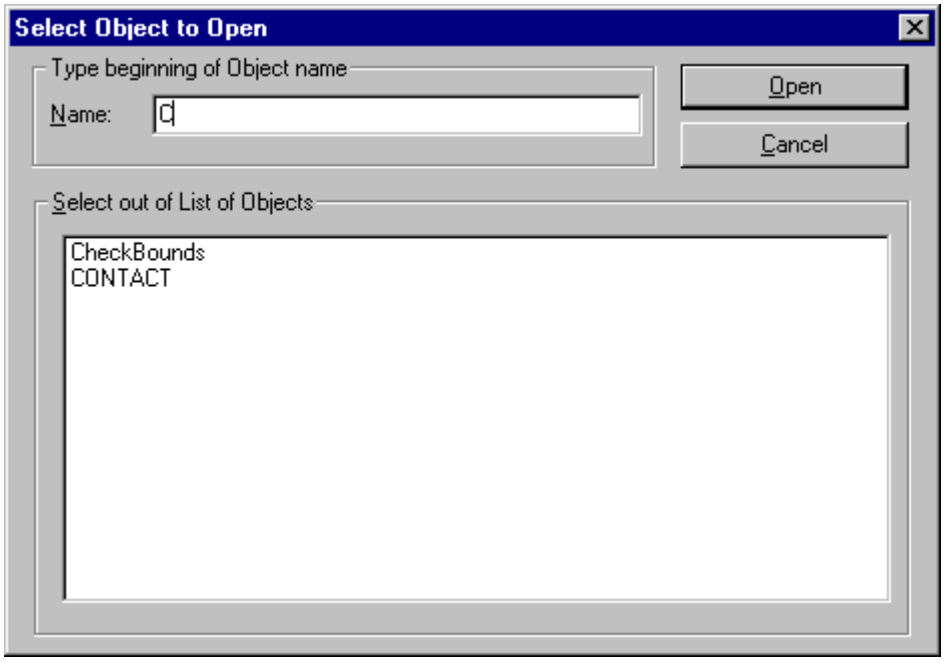
There are two other ways of opening an object:

- Doubleclick with the mouse on the desired object
- type in the Object Organizer the first letter of the object name. Then a dialog box opens in which all objects of the available object types with this initial letter are shown. Select the desired object and click on the button

Open in order to load the object in its edit window. This option is supported with the object type Resources only for global variables.

This last possibility is especially useful in projects with many objects.

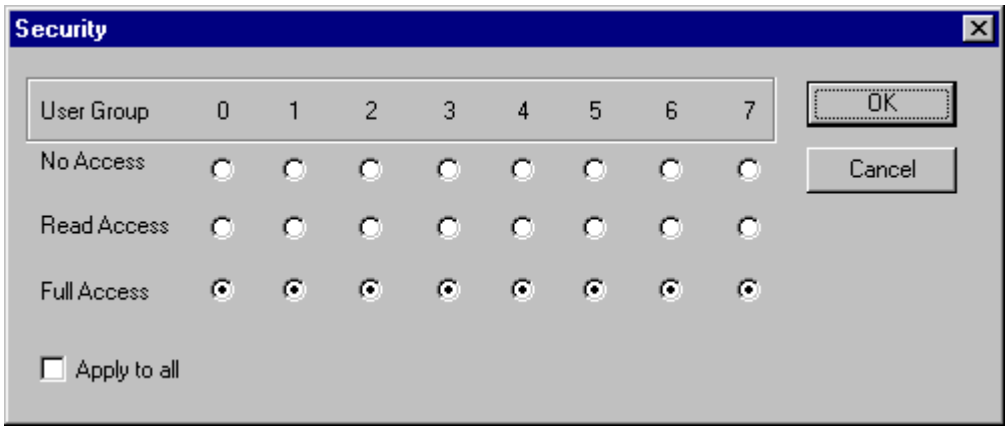
X Dialog box for choosing the object to be opened



4.4.11 'Project' 'Object Access rights'

With this command you open the dialog box for assigning access rights to the different user groups. The following dialog box appears:

X Dialog box for assigning access rights



Members of the user group 0 can now assign individual access rights for each user group. There are three possible settings:

- **No Access**: the object may not be opened by a member of the user group.
- **Read Access**: the object can be opened for reading by a member of the user group but not changed.

- **Full Access**: the object may be opened and changed by a member of the user group.

The settings refer either to the currently-selected object in the Object Organizer or, if the option **Apply to all** is chosen, to all POUs, data types, visualizations, and resources of the project.

The assignment to a user group takes place when opening the project through a password request if a password was assigned to the user group 0.

4.4.12 'Project' 'Object properties'

This command is only available if a global variable list in the Object Organizer is marked. It opens the dialog 'Global Variable List', in which the parameters for the updating of the list and, if applicable, for data exchange of network global variables, are configured. Entries can be changed here. When a new global variable list is created, this dialog is opened with the command 'Insert Object' if the folder 'Global Variables' or any entry above is marked in the Object Organizer.

4.4.13 'Project' 'Add Action'

This command is used to generate an action allocated to a selected block in the Object Organizer. One selects the name of the action in the dialog which appears and also the language in which the action should be implemented.

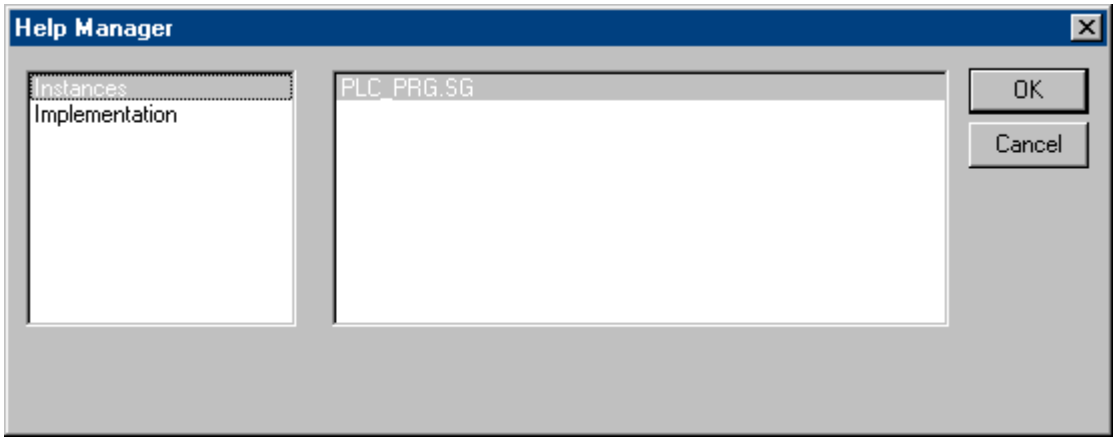
The new action is placed under your block in the Object Organiser. A plus sign appears in front of the block. A simple mouse click on the plus sign causes the action objects to appear and a minus sign appears in front of the block. Renewed clicking on the minus sign causes the actions to disappear and the plus sign appears again. This can also be achieved over the context menu commands 'Expand Node' and 'Collapse Node'**.**

4.4.14 'Project' 'Open Instance'

With this command it is possible to open and display the instance of the function block which is selected in the Object Organizer. In the same manner, a double click on the function block in the Object Organizer gives access to a selection dialog in which the instances of the function block as well as the implementation are listed. Select here the desired instance or the implementation and confirm using OK. The desired item is then displayed in a window.

Attention:
If you want to view instances, you first have to log in ! (The project has been compiled with no errors and downloaded to the PLC with 'Online' 'Login').

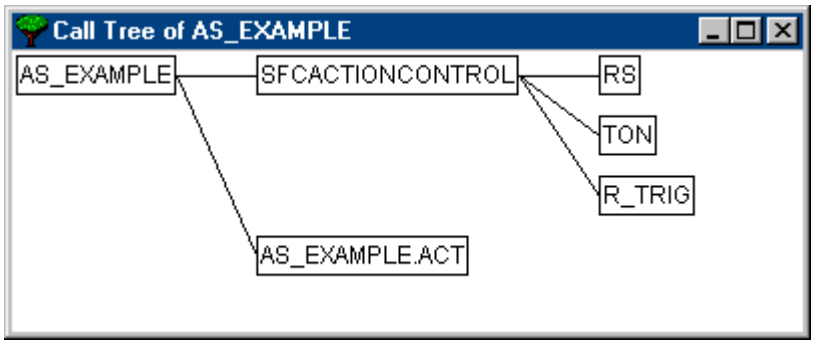
X Dialog for opening an instance



4.4.15 'Project' 'Show Call Tree'

With this command you open a window which shows the call tree of the object chosen in the Object Organizer. For this the project must be compiled (see 'Rebuild all'). The call tree contains both calls for POUs and references to data types.

X Example of a call tree



4.4.16 'Projekt' 'Show cross reference'

With this command you open a dialog box which makes possible the output of all application points for a variable, address, or a POU. For this the project must be compiled (see 'Project' 'Build'**).**

Choose first the **category** 'Variable', 'Address', or 'POU' and then enter the **name** of the desired element. To obtain all elements of the entered category enter a "*" in Name.

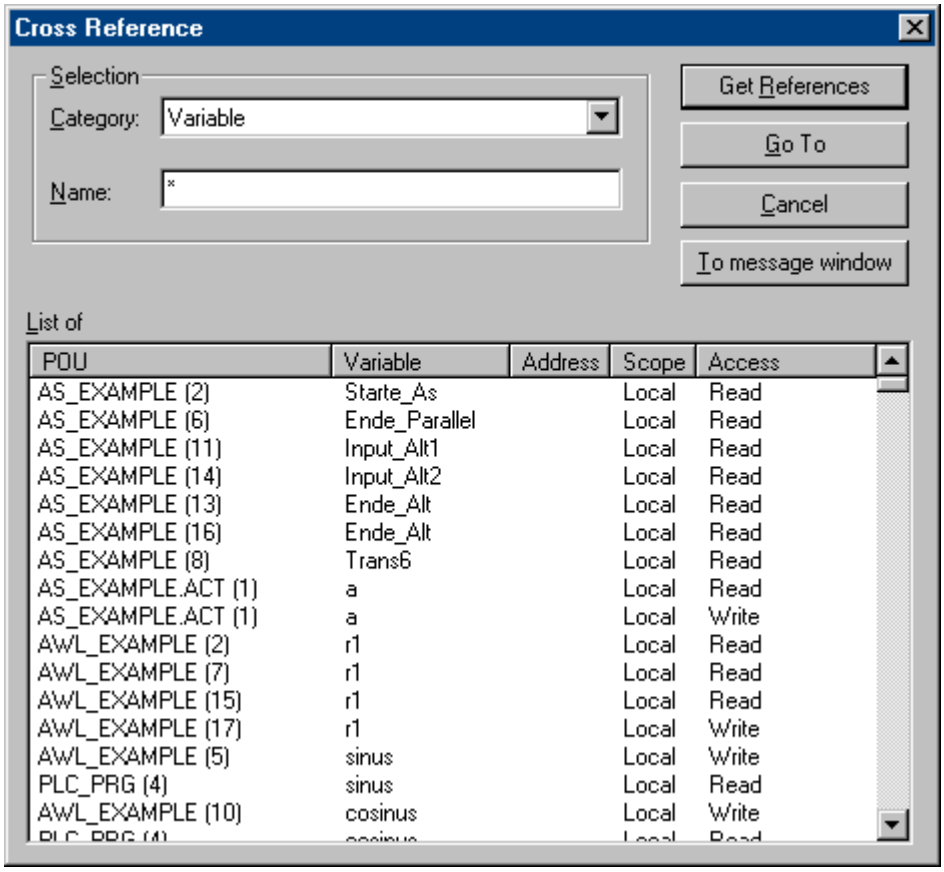
By clicking on the button **Cross References** you get the list of all application points. Along with the POU and the line or network number, the variable name and the address binding, if any, are specified. The Domain space shows whether this is a local or a global variable; the Access column shows whether the variable is to be accessed for ‚reading' or ‚writing' at the current location.

When you select a line of the cross reference list and press the button **Go To** or doubleclick on the line, then the POU is shown in its editor at the

corresponding point. In this way you can jump to all application points without a time-consuming search.

In order to make processing easier, you can use the **Send to message window** button to bring the current cross reference list into the message window and from there change to the respective POU.

X Dialog box and example of a cross reference list


Cross Reference
Selection
Category: Variable
Name: *
Get References
Go To
Cancel
To message window
List of
POU | Variable | Address | Scope | Access
AS_EXAMPLE (2) | Starte_As | Local | Read
AS_EXAMPLE (6) | Ende_Parallel | Local | Read
AS_EXAMPLE (11) | Input_Alt1 | Local | Read
AS_EXAMPLE (14) | Input_Alt2 | Local | Read
AS_EXAMPLE (13) | Ende_Alt | Local | Read
AS_EXAMPLE (16) | Ende_Alt | Local | Read
AS_EXAMPLE (8) | Trans6 | Local | Read
AS_EXAMPLE.ACT (1) | a | Local | Read
AS_EXAMPLE.ACT (1) | a | Local | Write
AWL_EXAMPLE (2) | r1 | Local | Read
AWL_EXAMPLE (7) | r1 | Local | Read
AWL_EXAMPLE (15) | r1 | Local | Read
AWL_EXAMPLE (17) | r1 | Local | Write
AWL_EXAMPLE (5) | sinus | Local | Write
PLC_PRG (4) | sinus | Local | Read
AWL_EXAMPLE (10) | cosinus | Local | Write

4.5 General Editing Functions

You can use the following commands in all editors and some of them in the Object Organizer. The commands are located under the menu item **'Edit'** and in the context menu that is opened with the right mouse button.

If the IntelliPoint-Software is installed on the computer, **WAGO-I/O-*PRO* 32** supports all functions of the MS IntelliMouse. In all editors with zoom functionality: To magnify press the **<Strg>** key while rolling the wheel of the mouse, to reduce roll backwards while the **<Strg>** key is pressed.

4.5.1 'Edit' 'Undo'

Shortcut: <Ctrl>+<Z>

This command undoes the action which was most recently executed in the currently-open editor window or in the Object Organizer; repeated use undoes

all actions back to the time that the window was opened. This applies to all actions in the editors for POUs, data types, visualizations and global variables and in the Object Organizer.

With 'Edit' 'Redo' you can restore an action which you have undone.

Note:
The commands Undo and Redo apply to the current window. Each window carries its own action list. If you want to undo actions in several windows, then you must activate the corresponding window. When undoing or redoing in the Object Organizer the focus must lie here.

4.5.2 'Edit' 'Redo'

Shortcut: <Ctrl>+<Y>

With the command in the currently-open editor window or in the Object Organizer you can restore an action you have undone ('Edit' 'Undo').

As often as you have previously executed the command 'Undo' , you can also carry out the command 'Redo'.

Note:
The commands 'Undo' and 'Redo' apply to the current window. Each window carries its own action list. If you want to undo actions in several windows, then you must activate the corresponding window. When undoing or redoing in the Object Manager must lie there.

4.5.3 'Edit' 'Cut'

Symbol: **Shortcut: <Ctrl>+<X> or <Shift>+<Delete>**

This command transfers the current selection from the editor to the clipboard. The selection is removed from the editor.

In the Object Organizer this similarly applies to the selected object, whereby not all objects can be deleted, e.g. the PLC Configuration.

Remember that not all editors support the cut command, and that its use can be limited in some editors.

The form of the selection depends upon the respective editor:

In the text editors IL, ST, and declarations the selection is a list of characters.

In the FBD and LD editors the choice is a number of networks which are indicated by a dotted rectangle in the network number field or a box with all preceding lines, boxes, and operands.

In the SFC editor the selection is a part of a series of steps surrounded by a dotted rectangle.

In order to paste the content of the clipboard you use the command 'Edit' 'Paste'. In the SFC editor you can also use the commands 'Extras' 'Insert parallel branch (right)' or 'Extras' 'Paste after'.

In order to copy a selection onto the clipboard without deleting it, use the command 'Edit' 'Copy'.

In order to remove a selected area without changing the clipboard, use the command 'Edit' 'Delete'.

4.5.4 'Edit' 'Copy'

Symbol: **Shortcut: <Ctrl>+<C>**

This command copies the current selection from the editor to the clipboard. This does not change the contents of the editor window.

With the Object Organizer this similarly applies to the selected object, whereby not all objects can be copied, e.g. the PLC Configuration.

Remember that not all editors support copying and that it can be limited with some editors.

For the type of selection the same rules apply as with 'Edit' 'Cut'.

The form of the selection depends upon the respective editor:

In the text editors (IL, ST, and declarations) the selection is a list of characters.

In the FBD and LD editors the choice is a number of networks which are indicated by a dotted rectangle in the network number field or a box with all preceding lines, boxes, and operands.

In the SFC editor the selection is a part of a series of steps surrounded by a dotted rectangle.

In order to paste the content of the clipboard you use the command 'Edit' 'Paste'. In the SFC editor you can also use the commands 'Extras' 'Insert parallel branch (right)' or 'Extras' 'Paste after'.

In order to delete a selected area and simultaneously put it on the clipboard, use the command 'Edit' 'Cut'.

4.5.5 'Edit' 'Paste'

Symbol: **Shortcut: <Ctrl>+<V>**

Pastes the content of the clipboard onto the current position in the editor window. In the graphic editors the command can only be executed when a correct structure results from the insertion.

With the Object Organizer the object is pasted from the clipboard.

Remember that pasting is not supported by all editors and that its use can be limited in some editors.

The current position can be defined differently according to the type of editor:

With the text editors (IL, ST, Declarations) the current position is that of the blinking cursor (a vertical line) which you place by clicking with the mouse).

In the FBD and LD editors the current position is the first network with a dotted rectangle in the network number area. The contents of the clipboard are inserted in front of this network. If a partial structure has been copied, then it is inserted in front of the selected element.

In the SFC editor the current position is determined the selection which is surrounded by a dotted rectangle. Depending upon the selection and the contents of the clipboard, these contents are inserted either in front of the selection or into a new branch (parallel or alternative) to the left of the selection.

In SFC the commands 'Extras' 'Insert parallel branch (right)' or 'Extras' 'Paste after' can be used in order to insert the contents of the clipboard.

In order to copy a selection onto the clipboard without deleting it, use the command 'Edit' 'Copy'.

In order to remove a selected area without changing the clipboard, use the command 'Edit' 'Delete'.

4.5.6 'Edit' 'Delete"

Shortcut: <Del>

Deletes the selected area from the editor window. This does not change the contents of the clipboard.

In the Object Organizer this applies likewise to the selected object, whereby not all objects can be deleted, e.g. the PLC Configuration.

For the type of selection the same rules apply as with 'Edit' 'Cut'.

The form of the selection depends upon the respective editor:

In the text editors (IL, ST, and declarations) the selection is a list of characters.

In the FBD and LD editors the selection is a number of networks which are highlighted with a dotted rectangle in the network number field.

In the SFC editor the selection is a part of a series of steps surrounded by a dotted rectangle.

In the library manager the selection is the currently selected library name.

In order to delete a selected area and simultaneously put it on the clipboard, use the command 'Edit' 'Cut'.

4.5.7 'Edit' 'Find'

Symbol:

With this command you search for a certain text passage in the current editor window. The Find dialog box opens. It remains opens until the button **Cancel** is pressed.

In the field **Find what** you can enter the series of characters you are looking for.

In addition, you can decide whether the text you are looking for **Match whole word only** or not, or also whether **Match case** is to be considered, and whether the search should proceed **Up** or **Down** starting from the current cursor position.

The button **Find next** starts the search which begins at the selected position and continues in the chosen search direction. If the text passages is found, then it is highlighted. If the passage is not found, then a message announces this. The search can be repeated several times in succession until the beginning or the end of the contents of the editor window has been reached.

Remember that the found text can be covered up by the Find dialog box.

X Find dialog box

4.5.8 'Edit' 'Find next'

Symbol: **Shortcut: <F3>**

With this command you execute a search with the same parameters as with the most recent action 'Edit' 'Find'.

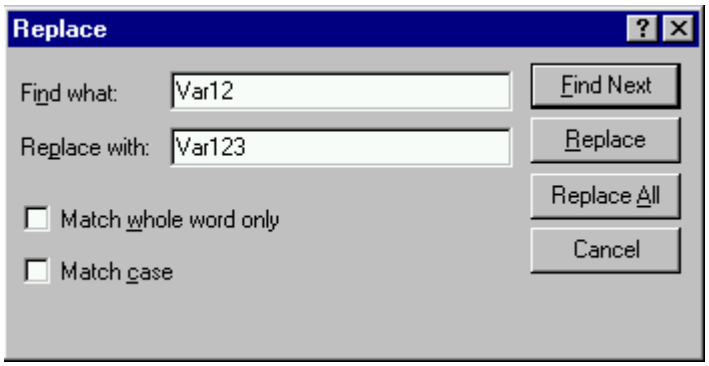
4.5.9 'Edit' 'Replace'

With this command you search for a certain passage just as with the command 'Edit' 'Find', and replace it with another. After you have chosen the command the dialog box for find and replace appears. This dialog box remains open until the button **Cancel** or **Close** is pressed.

The button **Replace** replaces the current selection with the text in the field **Replace with**.

The button **Replace all** replaces every occurrence of the text in the field **Find next** after the current position with the text in the field **Replace with**. At the end of the procedure a message announces how many replacements were made.

X Dialog box for find and replace



4.5.10 'Edit' 'Input Assistant'

Shortcut: <F2>

This command provides a dialog box for choosing possible inputs at the current cursor position in the editor window. In the left column choose the desired input category, select the desired entry in the right column, and confirm your choice with OK. This inserts your choice at this position.

The categories offered depend upon the current cursor position in the editor window, i.e. upon that which can be entered at this point (e.g. variables, operators, POUs, conversions, etc.).

If the option With arguments is active, then when the selected element is inserted, the arguments to be transferred are specified with it, for example: function block fu1 selected, which defines the input variable var_in: fu1(var_in:=);

Insertion of function func1, which uses var1 and var2 as transfer parameters: func1(var1,var2)

It is basically possible to switch between structured and unstructured display of the available elements. This occurs through activation/deactivation of the Structured Display option.

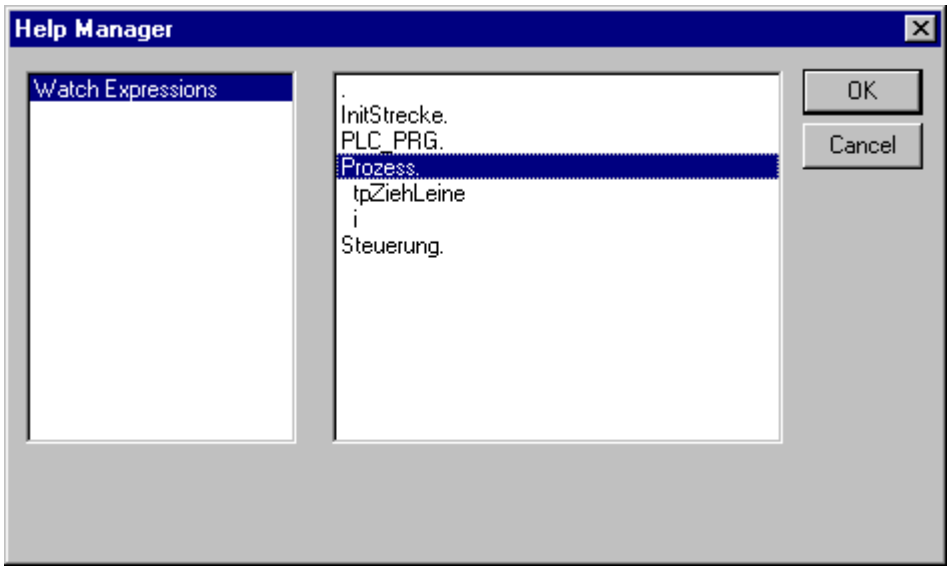
4.5.10.1 Unstructured Display

X Dialog for unstructured input assistance

The POUs, variables or data types in each category are simply sorted linearly in alphabetical order.

At various places (e.g. in the Watch List), multi-stage variable names are required. In that event, the Input Assistant dialog displays a list of all POUs as well as a single point for the global variables. After each POU name there is a point. If a POU is selected by doubleclick or by pressing <Enter>, a list of the variables belonging to it opens. If instances and data types are present, it is possible to open further levels in the hierarchy display. **OK** transfers the most recently selected variable.

You can switch to structured display through activation of the **Structured Display**



4.5.10.2 Stuctured Display

X Dialog for structured input assistance

If **Structured display** is selected, the POUs, variables or data types will be sorted hierarchically. This is possible for standard programs, standard functions, standard function blocks, defined programs, defined functions, defined function blocks, global variables, local variables, defined types, watch variables. The visual and hierarchical display corresponds to that of the Object Organizer; if elements in a library are referred to, these are inserted in alphabetical order at the very top and the pertinent hierarchy is displayed as in the Library Manager.

The **in- and output variables** of function blocks which are declared as local or global variables are listed in the category 'Local Variables' or 'Global Variables' under the instance name (e.g. Inst_TP ET, Inst_TP IN,...). To get there, select the instance name (e.g. Inst_TP) and confirm with **OK**.

If the **instance of a function block** is selected here, the option **With arguments** may be selected. In the text languages ST and IL as well as during task configuration, the instance name and the input parameters of the function block are then inserted.

For example, if Inst (DeklarationInst: TON;) is selected, the following is inserted:

```
Inst(IN:= ,PT:=)
```

If the option is not selected, only the instance name will be inserted. In the graphical languages or in the Watch window, only the instance name is generally inserted.

Components of **structures** are displayed in an analog fashion to function block instances.

For **enumerations**, the individual enumeration values are listed under the enumeration type. The order is: enumerations from libraries, enumerations from data types, local enumerations from POUs.

The general rule is that lines containing sub-objects are not selectable (except instances, see above), but can only have their hierarchy display expanded or contracted by one level, as for multi-stage variable names.

If Input Assistant is invoked in the Watch and Receipt Manager or in the selection of trace variables in the trace configuration dialog, it is possible to make a **multiple selection**. When the <Shift> key is pressed, you can select a range of variables; when the <Ctrl> key is pressed you can select many individual variables. The selected variables are so marked. If, during range selection lines are selected that do not contain valid variables (e.g. POU names), these lines will not be included in the selection. When individual selections are made, such lines can not be marked.

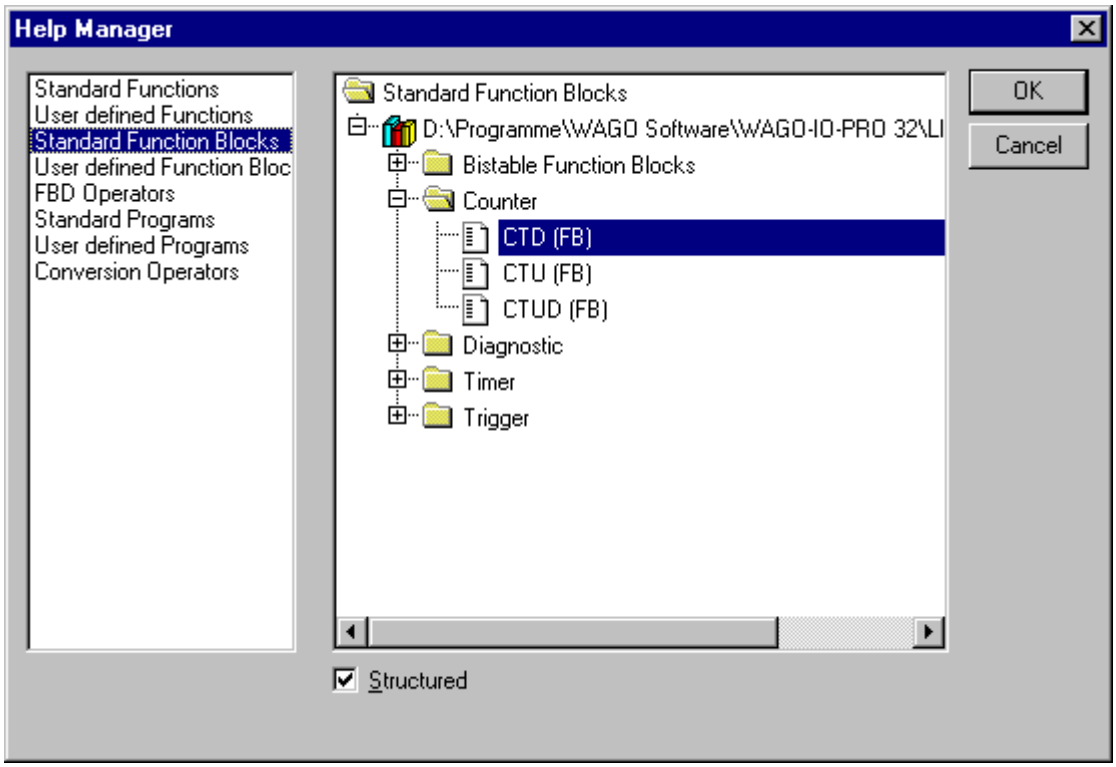
In the **watch window** and in **trace configuration** it is possible to transfer structures, arrays or instances from the Input Assistant dialog. As a double click with the mouse button is associated with the extension or contraction of the element's hierarchy display, selection in these cases can only be confirmed by **OK**.

Thereafter, the selected variables are inserted line by line in the watch window, that is each selected variable is written on a separate line. In the case of trace variables, each variable is inserted in a separate line of the trace variables list.

If the maximum number of trace variables, 20, is exceeded during insertion of the selected variables, the error message "A maximum of 20 variables is allowed" appears. Further selected variables are then not inserted in the list.

You can switch to unstructured display through deactivation of the **Structured Display**

Note:
Some entries (e.g. Global Variables) are only updated in the Input Assistant dialog after compilation.



4.5.11 'Edit''Declare Variable'

Shortcut: <Shift>+<F2>

This command opens the dialog for the declaration of a variable. This dialog also opens automatically when the option 'Project' 'Options' 'Editor' 'Autodeclaration' is switched on and when a new undefined variable is used the declaration editor.

4.5.12 'Edit' 'Next error'"

Shortcut: <F4>

After the incorrect compilation of a project this command can show the next error. The corresponding editor window is activated and the incorrect place is selected. At the same time in the message window the corresponding error message is shown.

4.5.13 'Edit' 'Previous error'"

Shortcut: <Shift>+<F4>

After the incorrect compilation of a project this command shows the previous error. The corresponding editor window is activated and the incorrect place is selected. At the same time in the message window the corresponding error message is shown.

4.5.14 'Edit' 'Macros'

This menu item leads to a list of all macros, which are defined for the project. (For info on generating macros see 'Project' 'Options' 'Macros'). When an executable macro is selected the dialog 'Process Macro'. The name of the macro and the currently active command line are displayed. The button Cancel can be used to stop the processing of the macro. In that event the processing of the current command will be finished anyway. Then an appropriate message is displayed in the message window and in the log during Online operation: "<Macro>: Execution interrupted by user".

Macros can be executed offline and online, but in each case only those commandes are executed which are available in the respective mode.

4.6 General Online Functions

The available online commands are assembled under the menu item **'Online'**. The execution of some of the commands depends upon the active editor.

The online commands become available only after logging in.

Thanks to 'Online Change' functionality you have the possibility of making changes to programs on the running controller. See in this connection 'Online' 'Log-in'

4.6.1 'Online-Change' Functionality

WAGO-I/O-*PRO* 32 version 2.2supports the ‘Online-Change‘-Functionality.

For the ‘Online-Change‘-Functionality are the following or newer controller-firmware version necessary.

750-842	Ethernet	09
750-837	CANopen	10
750-806	DeviceNet	04
750-833	Profibus	06
750-804	Interbus	08
750-819	LON	06

With the Modbus controller 750-812, 750-814, 750-815, 750-816 is the ‘Online-Change‘-Functionality not possible.

The ‘Online-Change’-functionality has to be activated before starting **WAGO-I/O-*PRO* 32**. Open the Windows Menu ***Start* \ *Programs* \ *WAGO-I/O-PRO 32** \ *Onlinechange Configuration*** (* or the folder name you have selected) and select the item ***Activate Onlinechange***. To deactivate the ‘Online-Change’-functionality select the item ***Deactivate Onlinechange***.

Note:
If the ‘Online-Change’-functionality is activated or deactivated for an already compiled project, this project has to be compiled again before loading.

Note:
The ‘Online-Change’-functionality needs twice as much memory area in the controller for the comparison of compiled code.

4.6.2 'Online' 'Login'

Symbol: **Shortcut: <Alt>+<F8>**

This command combines the programming system with the PLC (or starts the simulation program) and changes into the online mode.

If the current project has not been compiled since opening or since the last modification, then it is compiled now (as with 'Project' 'Build'). If errors occur during compilation, then **WAGO-I/O-*PRO* 32** does not change into Online mode.

If the current project was changed on the controller since the last download, but not closed, and if the last download information was not deleted with the command 'Project' 'Clear all', then after the command 'Login' a dialog opens with the question: "The program has been changed. Load changes? (Online Change)". By answering Yes you confirm that, on log-in, the modified portions of the project are to be loaded onto the controller. No results in a log-in without the changes made since the last download being loaded onto the controller. Cancel cancels the command. <Load all> causes the entire project to be reloaded onto the controller.

After a successful login all online functions are available (if the corresponding settings in 'Project' 'Options' category 'Build' have been entered). The current values are monitored for all visible variable declarations.

Use the 'Online' 'Logout' command to change from online back to offline mode.

4.6.3 If the system reports

Error:

"The selected controller profile does not match that of the target system..."

Check that the target system entered in the target system settings (Resources) matches the parameters entered in 'Online' 'Communications parameters'.

Error:

"Communication error. Log-out has occurred"

Check whether the controller is running. Check whether the parameters entered in **'Online' 'Communications parameters'** match those of your controller. In particular, you should check whether the correct port has been entered and whether the baud rates in the controller and the programming system match. If the gateway server is used, check whether the correct channel is set.

Error:

"The program has been modified! Should the new program be loaded?"

The project which is open in the editor is incompatible with the program currently found in the PLC (or with the Simulation Mode program being run). Monitoring and debugging is therefore not possible. You can either choose "No," logout, and open the right project, or use "Yes" to load the current project in the PLC.

Message:

"The program has been changed. Load changes? (ONLINE CHANGE)".

The project is running on the controller. The target system supports 'Online Change' and the project has been altered on the controller with respect to the most recent download or the most recent Online Change. You may now decide whether these changes should be loaded with the controller program running or whether the command should be cancelled. You can also, however, load the entire compiled code by selecting the **Load all** button.

4.6.4 'Online' 'Logout'

Symbol: **Shortcut <Strg>+<F8>**

The connection to the PLC is broken, or, the Simulation Mode program is ended and is shifted to the offline mode.

Use the 'Online' 'Login' command to change to the online mode.

4.6.5 'Online' 'Download'

This command loads the compiled project in the PLC.

If you use C-Code generation, then prior to the download, the C-Compiler is called up, which creates the download file. If this is not the case, then the download file is created during the compiling.

If you use C-Code generation, then prior to the download, the C-Compiler is called up, which creates the download file. If this is not the case, then the download file is created during the compilation.

The Download-Information is saved in a file called **<projectname>0000000ar.ri** , which is used during Online Change to compare the current program with the one most recently loaded onto the controller, so that only changed program components are reloaded. This file is erased by the command 'Project' 'Clear all'.

4.6.6 'Online' 'Run'

Symbol: **Shortcut: <F5>**

This command starts the program in the PLC or in Simulation Mode.

This command can be executed immediately after the 'Online' 'Download' command, or after the user program in the PLC has been ended with the 'Online' 'Stop' command, or when the user program is at a break point, or when the 'Online' 'Single Cycle' command has been executed.

4.6.7 'Online' 'Stop'

Symbol: **Shortcut <Shift>+<F8>**

Stops the execution of the program in the PLC or in Simulation Mode between two cycles.

Use the 'Online' 'Run' command to continue the program.

4.6.8 'Online' 'Reset'

If you have initialized the variables with a specific value, then this command will reset the variables to the initialized value. All other variables are set at a standard initialization (for example, integers at 0). As a precautionary measure, **WAGO-I/O-*PRO* 32** asks you to confirm your decision before all of the variables are overwritten. The situation is that which occurs in the event of a power failure or by turning the controller off, then on (warm restart).

Use the 'Online' 'Run' command to restart the program.

See also 'Online' 'Reset (original)' und 'Online' 'Reset (cold)'.

4.6.9 'Online' 'Reset (cold)'

This command resets all variables, including RETAIN variables, back to their initialization values. Only persistent variables retain the value that they had before the reset. See in this connection also 'Online' 'Reset' and 'Online' 'Reset Original'

4.6.10 'Online' 'Reset (original)'

This command resets all variables including the remanent ones (RETAIN and PERSISTENT) to their initialization values and erases the user program on the controller. The controller is returned to its original state. See in this connection also 'Online' 'Reset' and 'Online' 'Cold Reset'

4.6.11 'Online' 'Toggle Breakpoint'

Symbol: **Shortcut: <F9>**

This command sets a breakpoint in the present position in the active window. If a breakpoint has already been set in the present position, that breakpoint will be removed.

The position at which a breakpoint can be set depends on the language in which the POU in the active window is written.

In the Text Editors (IL, ST), the breakpoint is set at the line where the cursor is located, if this line is a breakpoint position (recognizable by the dark-gray color of the line number field). You can also click on the line number field to set or remove a breakpoint in the text editors.

In FBD and LD, the breakpoint is set at the currently selected network. In order to set or remove a breakpoint in the FBD or LD Editor, you can also click on the network number field.

In SFC, the breakpoint is set at the currently selected step. In SFC you can also use <Shift> with a doubleclick to set or remove a breakpoint.

If a breakpoint has been set, then the line number field or the network number field or the step will be displayed with a light-blue background color.

If a breakpoint is reached while the program is running, the program will stop, and the corresponding field will be displayed in a red background color. In order to continue the program, use the 'Online' 'Run', 'Online' 'Step in', or 'Online' 'Step Over' commands.

You can also use the Breakpoint dialog box to set or remove breakpoints.

4.6.12 'Online' 'Breakpoint Dialog Box'

This command opens a dialog box to edit breakpoints throughout the entire project. The dialog box also displays all breakpoints presently set.

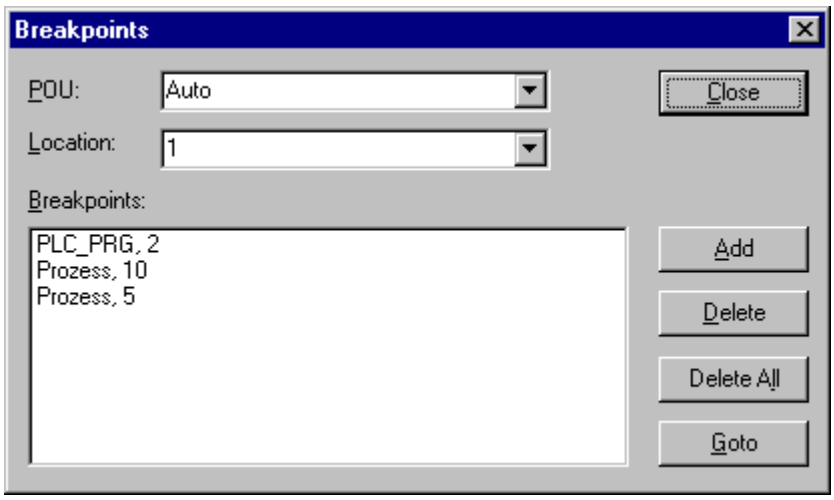
In order to set a breakpoint, choose a POU in the **POU** combobox and the line or the network in the **Location** combobox where you would like to set the breakpoint; then press the **Add** button. The breakpoint will be added to the list.

In order to delete a breakpoint, highlight the breakpoint to be deleted from the list of the set breakpoints and press the **Delete** button**.**

The **Delete All** button can be used to delete all the breakpoints.

In order to go to the location in the editor where a certain breakpoint was set, highlight the respective breakpoint from the list of set breakpoints and press the **Go to** button**.**

X Breakpoint Editing Dialog Box



To set or delete breakpoints, you can also use the 'Online' 'Toggle Breakpoint' command.

4.6.13 'Online' 'Step over'

Symbol: **Shortcut: <F10>**

This command causes a single step to execute. If a POU is called, the program stops after its execution. In SFC a complete action is executed.

If the present instruction is the call-up of a function or of a function block, then the function or function block will be executed completely. Use the 'Online' 'Step In' command, in order to move to the first instruction of a called function or function block.

If the last instruction has been reached, then the program will go on to the next instruction in the POU.

4.6.14 'Online' 'Step in'

Shortcut: <F8>

A single step is executed. The program is stopped before the first instruction of a called POU.

If necessary, there will be a changeover to an open POU.

If the present position is a call-up of a function or of a function block, then the command will proceed on to the first instruction in the called POU.

In all other situations, the command will function exactly as 'Online' 'Step Over'.

4.6.15 'Online' 'Single Cycle'

Shortcut: <Ctrl>+<F5>

This command executes a single PLC Cycle and stops after this cycle.

This command can be repeated continuously in order to proceed in single cycles.

The Single Cycle ends when the 'Online' 'Run' command is executed.

4.6.16 'Online' 'Write values'

Shortcut: <Ctrl>+<F7>

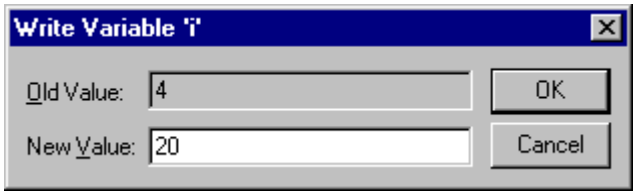
With this command, one or more variables are set – one time only! – to user defined values at the beginning of a cycle. (see 'Online' 'Force values' for setting permanently)

The values of all single-element variables can be changed, so long as they are also visible in Monitoring.

Before the command 'Write values' can be executed, a variable value must be ready to be written:

For non-boolean variables a double mouse click in performed on the line in which a variable is declared, or the variable is marked and the <Enter> key is pressed. The dialog box 'Write variable <x>' then appears, in which the value to be written to the variable can be entered.

X Dialog for writing of variables



For boolean variables, the value is toggled (switched between TRUE and FALSE, with no other value allowed) by double-clicking on the line in which the variable is declared; no dialog appears.

The value set for Writing is displayed in brackets and in turquoise colour behind the former value of the variable. e.g. a=0 <:=34>.

Note:
Exception: In the FBD and LD Editor the value is shown turquoise without brackets next to the variable name.

Set the values for as many variables as you like.

The values entered to be written to variables can also be corrected or deleted in the same manner. This is likewise possible in the 'Online' 'Write/Force dialog' (see below).

The values to be written that were previously noticed are saved in a **writelist (Watchlist)**, where they remain until they are actually written, deleted or transferred to a forcelist by the command 'Force values'.

The command to Write Values can be found at two places:

- Command 'Write Values' in the menu 'Online'.
- Button 'Write Values' in the dialog 'Editing the writelist and the forcelist'.

When the command 'Write values' is executed, all the values contained in the writelist are written, once only , to the appropriate variables in the controller at the beginning of the cycle, then deleted from the writelist. (If the command 'Force values' is executed, the variables in question are also deleted from the writelist, and transferred to the forcelist!)

Note:
In the sequential function chart language (SFC), the individual values from which a transition expression is assembled cannot be changed with 'Write values'. This is due to the fact that in monitoring the 'Total value' of the expression, not the values of the individual variables are displayed (e.g. "a AND b" is only displayed as TRUE if both variables actually have the value TRUE).

In FBD, on the other hand, only the first variable in an expression, used for example as input to a function block, is monitored. Thus a 'Write values' command is only possible for this variable.

4.6.17 'Online' 'Force values'

Shortcut: <F7>

With this command, one or more variables are permanently set (see 'Online' 'Write values' for setting only once at the beginning of a cycle) to user-defined values. The setting occurs in the run-time system, both at the beginning and at the end of the cycle.

The time sequence in one cycle: 1.Read inputs, 2. Force values 3. Process code, 4. Force values 5. Write outputs.

The function remains active until it is explicitly suspended by the user (command 'Online' 'Release force') or the programming system is logged-out.

For setting the new values, a **writelist** is first created, just as described under 'Online' 'Write values'. The variables contained in the writelist are accordingly marked in Monitoring. The writelist is transferred to a **forcelist** as soon as the command 'Online' 'Force values' is executed. It is possible that an active forcelist already exists, in which case it is updated as required. The writelist is then emptied and the new values displayed in red as 'forced'. Modifications of the forcelist are transferred to the program with the next 'Force values' command.

Note:
The forcelist is created at the first forcing of the variables contained in the writelist, while the writelist existed prior to the first writing of the variables that it contains.

The command for forcing a variable, which means that it will be entered into the forcelist can be found at the following places:

- Command 'Force Values' in the menu 'Online'.
- Button 'Force Values' in the dialog 'Editing the writelist and the forcelist'.

Note:
In the sequential function chart language, the individual values from which a transition expression is assembled cannot be changed with 'Force values'. This is due to the fact that in monitoring the 'Total value' of the expression, not the values of the individual variables are displayed (e.g. "a AND b" is only displayed as TRUE if both variables actually have the value TRUE).

In FBD, on the other hand, only the first variable in an expression, used for example as input to a function block, is monitored. Thus a 'Force values' command is only possible for this variable.

4.6.18 'Online' 'Release force'

Shortcut: <Shift>+<F7>

This command ends the forcing of variable values in the controller. The variable values change again in the normal way.

Forced variables can be recognized in Monitoring by the red color in which their values are displayed. You can delete the whole forcelist, but you can also mark single variables for which the forcing should be released.

To delete the whole forcelist, which means to release force **for all variables**, choose one of the following ways:

- Command 'Release Force' in menu 'Online'.
- Button 'Release Force' in dialog 'Editing the writelist and the forcelist'

- Delete the whole forcelist using the command 'Release Force' in the dialog 'Remove Write-/Forcelist'. This dialog opens if you choose the command 'Release Force' while also a writelist exists.

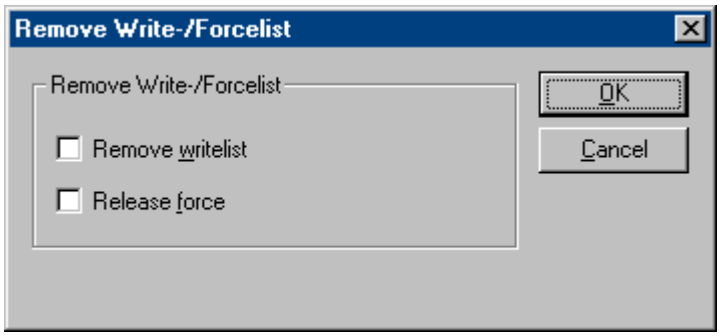
To release force only **for single variables** you have to mark these variable first. Do this in one ways described in the following. After that the chosen variables are marked with an turquoise extension <Release Force>:

- A double mouse click on a line, in which a non boolean variable is declared, opens the dialog 'Write variable <x>'. Press button <Release Force for this variable> .
- Repeat double mouse clicks on a line in which a boolean variable is declared to toggle to the display <Release Force> at the end of the line.
- In the menu 'Online' open the Write/Force-Dialog and delete the value in the edit field of the column 'Forced value'.

When for all desired variables the setting "<Release Force>" is shown in the declaration window, choose the command 'Force values' to transfer the modifications of the forcelist to the program.

If the current writelist (see 'Online' 'Write Values') is not empty while you execute the command 'Release Force', the dialog 'Remove Write-/Forcelist' will be opened. There the user has to decide whether he just wants to **Release Force** or additionally wants to **Remove the writelist** or if he wants to remove both lists.

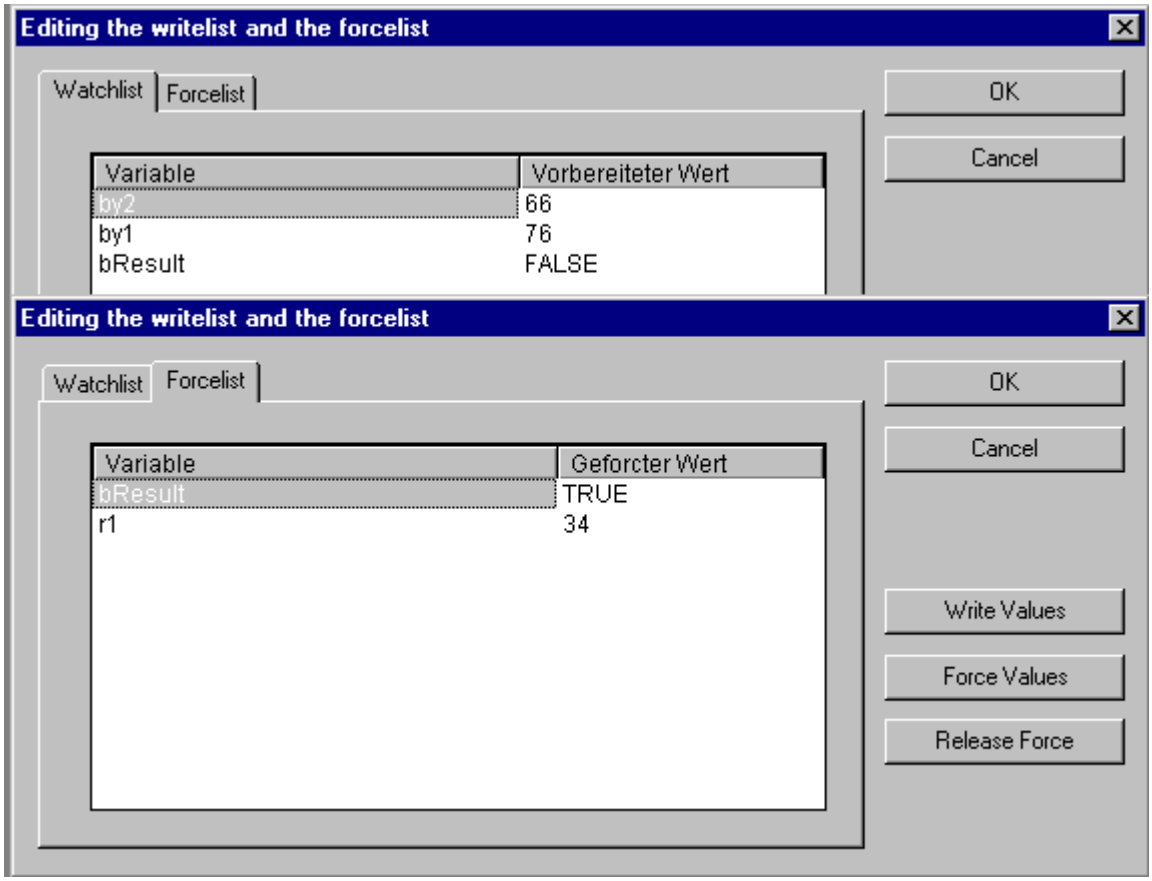
X Dialog for removing Write-/Forcelists



4.6.19 'Online' 'Write/Force' Dialog'

This command leads to a dialog which displays in two registers the current writelist (**Watchlist**) and forcelist (**Forcelist**). Each variable name and the value to be written to it or forced on it are displayed in a table.

X Dialog for editing the writelist and the forcelist



The variables reach the watchlist via the commands 'Online' 'Write Values' and are transferred to the forcelist by the command 'Online' 'Force Values'. The values can be edited here in the "Prepared Value" or "Forced Value" columns by clicking the mouse on an entry to open an editor field. If the entry is not type-consistent, an error message is displayed. If a value is deleted, it means that the entry is deleted from the writelist or the variable is noticed for suspension of forcing as soon as the dialog is closed with any other command than **Cancel**.

The following commands, corresponding to those in the Online menu, are available via buttons:

Force Values: All entries in the current writelist are transferred to the forcelist, that is the values of the variables in the controller are forced. All variables marked with 'Release Force' are no longer forced. The dialog is then closed.

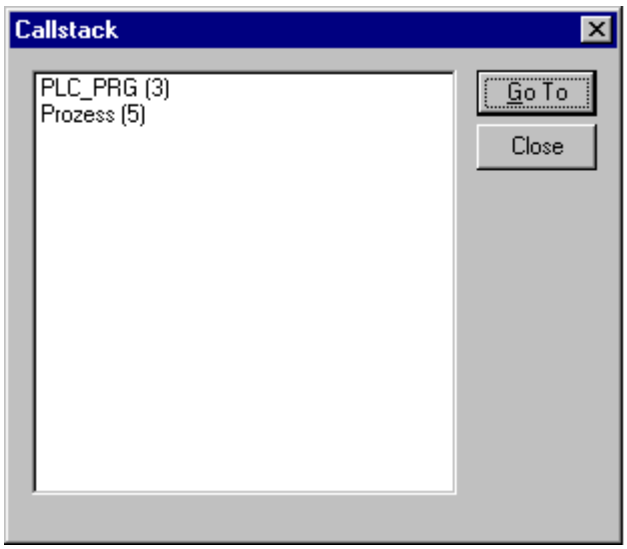
Write Values: All entries in the current writelist are written once only to the corresponding variables in the controller. The dialog is then closed.

Release Force: All entries in the forcelist will be deleted or, if a writelist is present, the dialog "Delete write-/forcelist" comes up, in which the user must decide whether he only wants to **release forcing** or **discard the writelist**, or both. The dialog will close at that point, or after the selection dialog is closed as the case may be.

4.6.20 'Online' 'Show Call Stack'

You can run this command when the Simulation Mode stops at a breakpoint. You will be given a dialog box with a list of the POU Call Stack.

X Example of a Call Stack



The first POU is always PLC_PRG, because this is where the executing begins.

The last POU is always the POU being executed.

After you have selected a POU and have pressed the **Go to** button, the selected POU is loaded in its editor, and it will display the line or network being processed.

4.6.21 'Online' 'Flow Control'"

If you have selected the **flow control**, then a check(✓) will appear in front of the menu item. Following this, every line or every network will be marked which was executed in the last PLC Cycle.

The line number field or the network number field of the lines or networks which just run will be displayed in green. An additional field is added in the IL-Editor in which the present contents of the accumulator are displayed. In the graphic editors for the Function Block Diagram and Ladder Diagram, an additional field will be inserted in all connecting lines not transporting any Boolean values. When these Out- and Inputs are verified, then the value that is transported over the connecting line will be shown in this field. Connecting lines that transport only Boolean values will be shaded blue when they transport TRUE. This enables constant monitoring of the information flow.

4.6.22 'Online' 'Simulation'

If **Simulation Mode** is chosen, then a check(✓) will appear in front of the menu item.

In the simulation mode, the user program runs on the same PC under Windows. This mode is used to test the project. The communication between the PC and Simulation Mode uses the Windows Message mechanism.

If the program is not in simulation mode, then the program will run on the PLC. The communication between the PC and the PLC typically runs over the serial interface.

The status of this flag is stored with the project.

4.6.23 'Online' 'Communication Parameters'

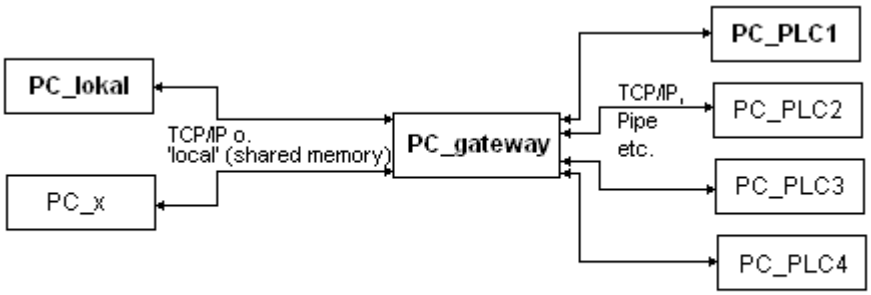
You are offered a special dialog for setting communication parameters when the communication between the local PC and the run-time system is running over a gateway server in your system. (If the OPC or DDE server is used, the same communications parameters must be entered in its configuration).

4.6.24 Principle of a gateway system

Let us examine the principle of the gateway system before explaining the operation of the dialog:

A gateway server can be used to allow your local PC to communicate with one or more run-time systems. The setting concerning which run-time systems can be addressed, which is specifically configured for each gateway server, and the connection to the desired gateway server, is made on the local PC. Here it is possible that both the gateway server and the run-time system(s) can run together on the local PC. If we are dealing with a gateway server which is running on another PC we must ensure that it has been started there. If you are selecting a locally installed gateway server, it automatically starts when you log onto the target run-time system. You can recognise this through the appearance of a **WAGO-I/O-*PRO* 32** symbol on the bottom right in the task bar. This symbol lights up as long as you are connected to the run-time system over the gateway. The menu points **Info** and **Finish** are obtained by clicking with the right mousekey on the symbol. **Finish** is used to switch off the gateway.

See the following scheme for presenting a gateway system:



PC_local is your local PC, **PC_x** is another PC, which gateway addresses. **PC_gateway** is the PC on which the gateway server is installed, **PC_PLC1** through to **PC_PLC4** are PCs on which the run-time systems are running. The diagram shows the modules as separated but it is fully possible for the Gateway server and / or run-time systems to be installed together on the local PC.

Note:
Please note that a connection to gateway is only possible over TCP/IP so make sure that your PC is configured appropriately!

The connections from gateway to the various run-time computers can, on the other hand, run over different protocols (TCP/IP, Pipe, etc.).

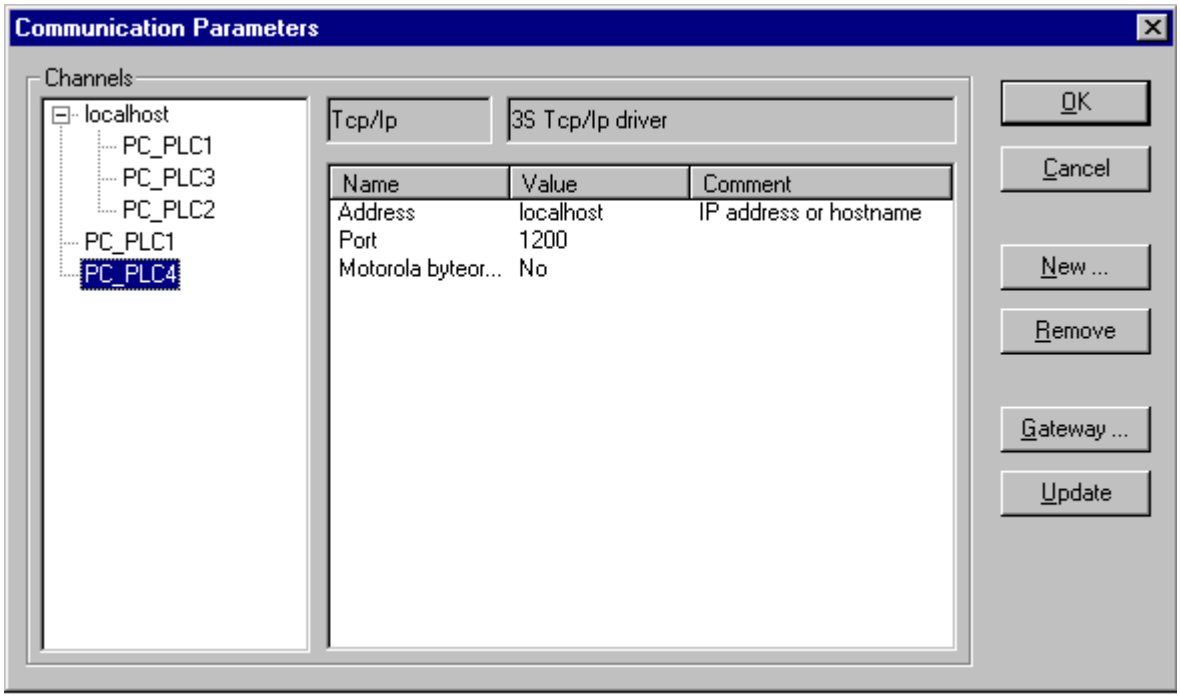
4.6.25 What the communications parameters dialog on the local PC shows

This dialog is used to select a gateway server for the communicatio with a PLC. Furtheron there can be set up channels for a gateway server which is installed on the local PC so that these channels can be used by other computers which are part of the network.

The current settings can be called up at any time using the button **Update**.

The dialog will appear as follows if the communications parameters have already been configured according to the example in 'Principle of a gatewa system'.:

x Dialog for setting the gateway communications parameters, example



The heading **Channels** lists two categories of connections:

On the one hand all of the connections are shown which are installed on the currently connected gateway server called 'localhost'. Here the address or the name of this gateway is located on the upper position behind the minus sign, which in our example is running on the local computer. The appropriate address 'localhost' corresponds in the normal case to the IP address 127.0.0.1 of the local computer (PC_local). Below, indented to the right, are three addresses of run-time computers which the gateway channels are set-up to (PC_PLC1 to 3). They could have been configured both from the local PC or from the other PCs (PC_x) which are or were connected to the gateway server.

The second category of the channels describes includes all connections to the gateway which can be set up from your local PC, over this configuration dialog for example. They create the "branch" which leads from the minus sign directly below to PC_PLC1 and PC_PLC4. These channel addresses do not necessarily have to be known yet at the gateway. For PC_PLC4 in the example described above, the configuration parameters are stored locally in the project but they will first be known to the gateway the next time log-in to the run-time system occurs. This has already occurred for PC_PLC1 since the associated gateway address has appeared as an additional "sub-branch" to the "channel tree".

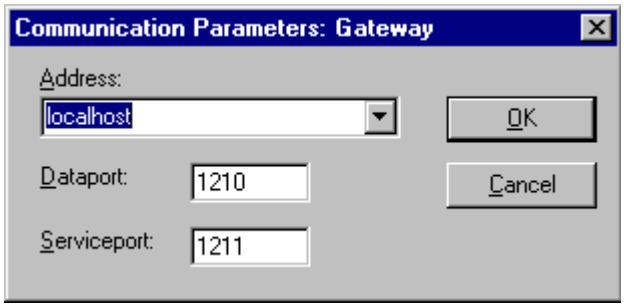
In the central part of the dialog one finds the designation, in each case, of the left selected channel and the associated parameter under **Name**, **Value** and **Comment**.

4.6.26 Setting up the desired gateway server and channel

Setting up the desired gateway server and channel

To define the connection to the desired gateway server we open the dialog 'Communication Parameters Gateway' by pressing the button **Gateway**.

X Example dialog, definition of the local connection to the gateway



Here you can enter and/or edit the following:

- The type of **connection** from your computer to the computer on which the gateway server that you want to use is running. If the gateway server is running on the local computer, connection via shared memory ("local") or via TCP/IP is possible; if connection to a different computer is needed, only TCP/IP can be used.
- The **address** of the computer, on which the gateway server that you want to use is running: IP address or the appropriate symbolic name such as e.g. localhost. On initial setup, the standard 'localhost' is offered as the computer name (address), which means that the locally installed gateway would be accessed. The name 'localhost' is set to be identical to the local IP address 127.0.0.1 in most cases, but you may in some cases have to enter this directly into the Address field. If you want to access a gateway server on another computer, you must replace 'localhost' with its name or IP address.
- The **password** for the selected gateway server, if it is on a remote computer. If it is incorrectly entered, or not entered at all, an error message appears.
  Note in this connection: you can give the locally installed gateway server a password with the following procedure: click with the right mouse button on the gateway symbol in the lower right portion of the toolbar and select "Change password". A dialog comes up for changing or entering a password. If you access the gateway server locally any password that is entered will not be asked for.
- The computer's **port** on which the gateway server that you wish to use is running, as a rule the correct value for the selected gateway is already given.

If the dialog is closed with **OK**, the corresponding entry (computer address) appears in the **Channels** field at the top of the 'Communication parameters' dialog, and below it the channels available on this gateway server.

Setting up the desired channel on the selected gateway server:

Now select one of the channels by clicking on an entry with the mouse. The corresponding parameters will then be shown in the table. If no connection can

be established to the selected gateway address — possibly because it has not been started or the address is incorrect — the phrase 'not connected' appears in brackets after the address and a message 'No gateway with these settings could be found' appears. In this connection, see for further information under 'Quick check in the event of unsuccessful connection attempt to gateway'.

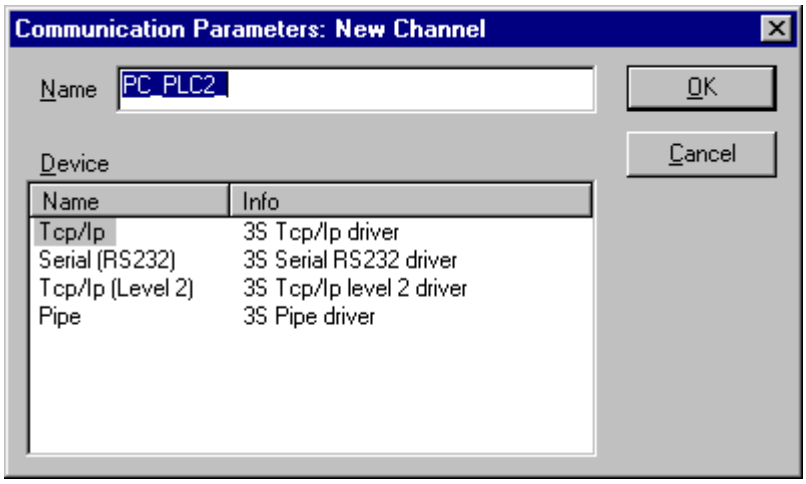
Once the desired channel is set up, close the dialog using **OK**. The settings are saved with the project.

4.6.27 Setting up a new channel for the local gateway server

You can set up new channels for the currently connected gateway server, which are then available for establishing further connection from the server, a connection to a controller for example. The options that you have in this regard depend on the particular choice of the number of device drivers installed on your computer.

Press the **New** button. The dialog 'Communication Parameters: New Channel' comes up:

X Example dialog, installing a new channel



The input field **Name** automatically contains the name used for the last inputted channel. If no channel has yet been defined, the current gateway name will be offered, followed by an underline character , e.g. 'localhost_'. You can edit the channel name at this point. The channel name is purely informative, it does not have to be a unique name but it is recommended to use one.

The device drivers available on the gateway computer are listed in the table under **Device**. In the **Name** column, select by mouse click one of the available drivers; the corresponding comment, if any, appears in the **Info** column.

If you close the '...New Channel' dialog with **OK**, the newly defined channel appears in the 'Communication Parameters' dialog as a new entry in **Channels** at the lowest position under the minus sign. So far, it is only stored locally in the project (see above). At this point you can edit the **Value** column (see tips

below). Now confirm the entered parameters with **OK**, thus leaving the 'Communication Parameters' dialog.

In order for the newly entered gateway channel and its parameters to also be known to the gateway server xy, and thus also to make it available to other computers that access this gateway xy, you must log into the run-time system. If you then re-open the 'Online' 'Communication parameters' dialog, the new channel appears in the "channel tree", not only in its previous position but also indented under the address or name of the gateway server xy. This indicates that it is known to the network. You can now open the Communication Parameter dialog on a computer other than the local one, select gateway xy and use its new channel.

If a communications error occurs when logging in, it is possible that the interface cannot be opened (e.g. COM1 for a serial connection) possibly because it is being used by another device. It is also possible that the controller is not running.

The parameters for a channel already known by the gateway server can no longer be edited in the configuration dialog. The parameter fields appear grey. You can, however, delete the connection as long as it is not active.

Note:
Please not that the deletion of a channel is not reversible. It occurs at the moment that you press on the button **Remove**!

4.6.28 Tips for editing the parameters in the communications parameters dialogue

You can only edit the text fields in the column **Value**.

Select a text field with the mouse, and get into the editing mode by double clicking or by pressing the space bar. The text input is finished by pressing the <Enter> key.

You can use **<Tabulator>** or **<Shift>** + **<Tabulator>** to jump to the next or the previous switching or editing possibility.

To edit numerical values it is possible with the arrow keys or the Page Up/Down keys to change the value by one or ten units respectively. A double click with the mouse also changes the value by increasing by one unit. A typing check is installed for numerical values: **<Ctrl>** + **<Home>** or **<Ctrl>** + **<End>** deliver the lowest or the highest value respectively for the possible input values for the type of parameter in question.

4.6.29 Quick check in the event of unsuccessful connection attempt to the gateway

You should make the following checks if the connection to the selected gateway computer is not successful. (You get the message "not connected" in

the Communication Parameters dialog behind the gateway server address in the field Channels):

- Has the gateway server been started (the three-color symbol appears in the bottom right portion of the toolbar) ?
- Is the IP address that you entered in the 'Gateway: Communication Parameters' dialog really that of the computer on which the gateway is running ? (use "ping" to check)
- Is the TCP/IP connection working locally? The error may possibly lie with TCP/IP.

4.6.30 'Online' 'Sourcecode download'

This command loads the source code for the project into the controller system. This is not to be confused with the Code that is created when the project is compiled! You can enter the options that apply to Download (time, size) in the 'Project' 'Options' 'Sourcedownload' dialog.

4.6.31 'Online' 'Create bootproject'

With this command, the compiled project is set up on the controller in such a way that the controller can load it automatically when restarted. Storage of the boot project occurs differently depending on the target system. For example, on 386 systems three files are created: **default.prg** contains the project code, **default.chk** contains the code's checksum, **default.sts** contains the controller status after restart (start/stop).

The command 'Online' 'Create bootproject' is also available in **offline mode** if the project has been built without errors. In this case the following files are created in the projects directory: **<projektname>.prg** for the bootproject code, and **projektname>.chk** for the checksum. These files can be renamed as necessary and then be copied to a PLC.

4.6.32 'Online' 'Write file to controller'

This command is used for loading any desired file onto the controller. It opens the dialog for 'Write file to controller' in which you can select the desired file.

After the dialog is closed using the 'Open' button, the file is loaded into the controller and stored there under the same name. The loading process is accompanied by a progress dialog.

With the command 'Online' 'Load file from controller' you can retrieve a file previously loaded on the controller.

4.6.33 'Online' 'Load file from controller'

With this command, you can retrieve a file previously loaded into the controller using 'Online' 'Write file to controller'. You receive the 'Load file from controller' dialog. Under Filename, provide the name of the desired file,

and in the selection window enter the directory on your computer into which it is to be loaded as soon as the dialog is closed with the "Save" button.

4.7 Log

The log stores in chronological order actions that occur during an Online session. For this purpose a binary log file (*.log) is set up. Afterward, the user can store excerpts from the appropriate project log in an external log.

The log window can be opened in either Offline or Online mode and can thus serve as a direct monitor online.

4.7.1 'Window' 'Log'

To open, select the menu item 'Window' 'Log'.

X Log window

In the log window, the filename of the currently displayed log appears after **Log:**. If this is the log of the current project, the word "(Internal)" will be displayed.

Registered entries are displayed in the log window. The newest entry always appears at the bottom.

Only actions belonging to categories that have been activated in the 'Filter' field of the menu 'Project' 'Options' 'Log' will be displayed.

Available information concerning the currently selected entry is displayed below the log window:

Category: The category to which the particular log entry belongs. The following four categories are possible:

- User action: The user has carried out an Online action (typically from the Online menu).
- Internal action: An internal action has been executed in the Online layer (e.g. Delete Buffers or Init Debugging).
- Status change: The status of the runtime system has changed (e.g. from Running to Break, if a breakpoint is reached).
- Exception: An exception has occurred, e.g. a communication error.

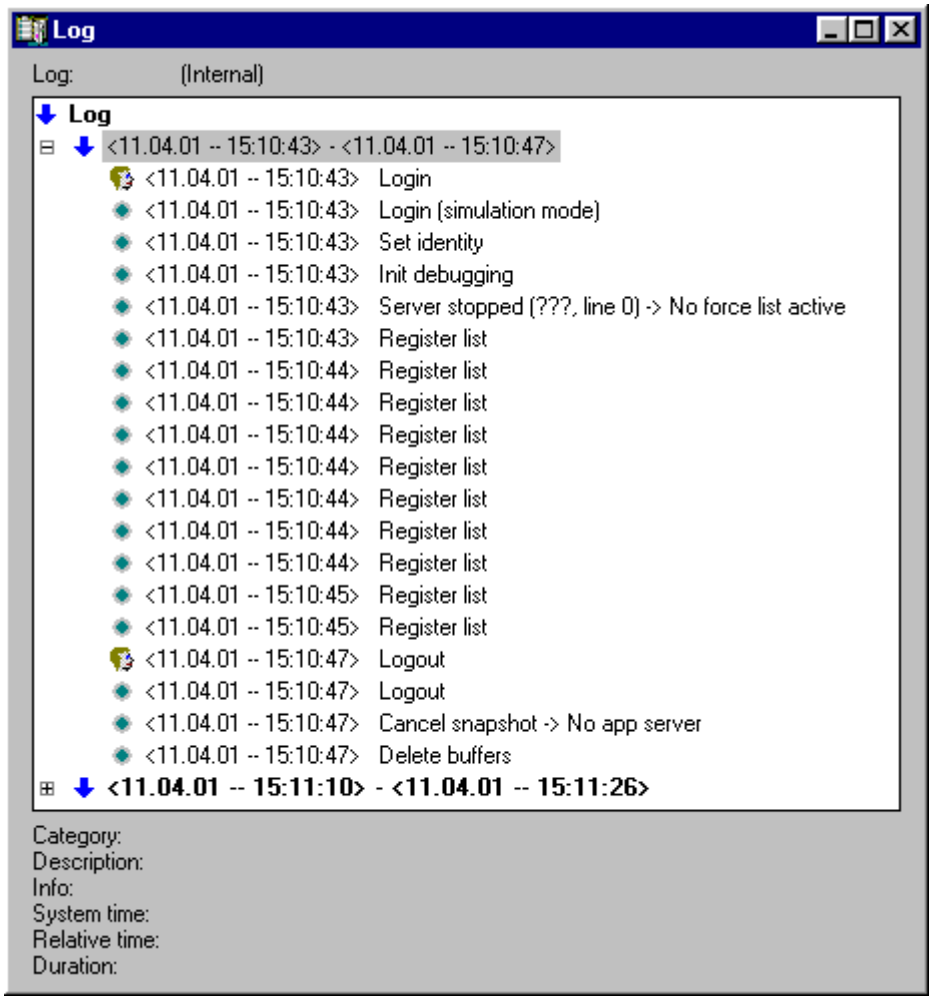
Description: The type of action. User actions have the same names as their corresponding menu commands; all other actions are in English and have the same name as the corresponding `OnlineXXX()` function.

Info: This field contains a description of an error that may have occurred during an action. The field is empty if no error has occurred.

System time: The system time at which the action began, to the nearest second.

Relative time: The time measured from the beginning of the Online session, to the nearest millisecond.

Duration: Duration of the action in milliseconds.



4.7.2 Menu Log

When the log window has the input focus, the menu option **Log** appears in the menu bar instead of the items 'Extras' and 'Options'.

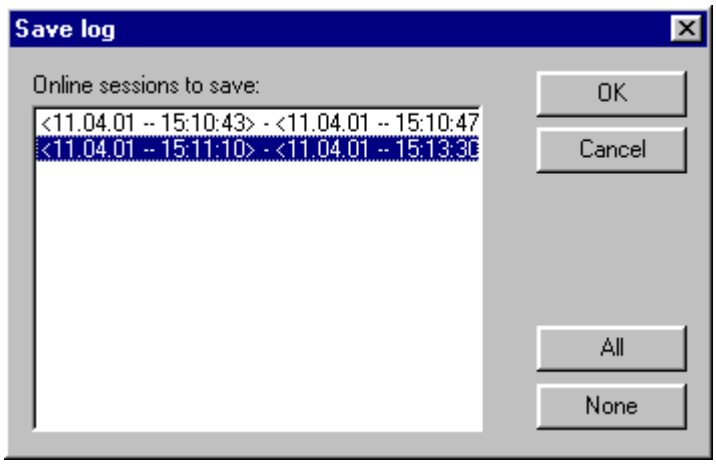
The menu includes the following items:

Load… An external log file *.log can be loaded and displayed using the standard file open dialog.

The log that is present in the project will not be overwritten by the command. If the log window is closed and later opened again, or a new Online session is started then the version that is loaded will again be replaced by the project log.

Save…

This menu item can only be selected if the project log is currently displayed. It allows an excerpt of the project log to be stored in an external file. For that, the following dialog will be displayed, in which the Online sessions to be stored can be selected:



After successful selection, the standard dialog for storing a file opens ('Save Log').

Display Project Log

This command can only be selected if an external log is currently displayed. It switches the display back to the project log.

4.7.3 Storing the project log

Regardless of whether or not the log is stored in an external file (see above), the project log is automatically stored in a binary file entitled <projectname>.log. If a different path is not explicitly given in the 'Project' 'Options' 'Log' dialog, the file is stored in the same directory as that in which the project is stored.

The maximum number of Online sessions to be stored can be entered in the 'Project' 'Options' 'Log' dialog. If this number is exceeded during recording, the oldest session is deleted to make room for the newest one.

4.8 Window set up

Under the **'Window'** menu item you will find all commands for managing the windows. There are commands both for the automatic set up of your window as well as for opening the library manager and for changing between open windows. At the end of the menu you will find a list of all open windows in the sequence they were opened. You can switch to the desired window by clicking the mouse on the relevant entry. A check will appear in front of the active window.

4.8.1 'Window' 'Tile Horizontal'

With this command you can arrange all the windows horizontally in the work area so that they do not overlap and will fill the entire work area.

4.8.2 'Window' 'Tile Vertical'

With this command you can arrange all the windows vertically in the work area so that they do not overlap and will fill the entire work area.

4.8.3 'Window' 'Cascade'

With this command you can arrange all the windows in the work area in a cascading fashion, one behind another.

4.8.4 'Window' 'Arrange Symbols'

With this command you can arrange all of the minimized windows in the work area in a row at the lower end of the work area.

4.8.5 'Window' 'Close All'

With this command you can close all open windows in the work area.

4.8.6 'Window' 'Messages'

Shortcut: <Shift>+<Esc>

With this command you can open or close the message window with the messages from the last compiling, checking, or comparing procedure.

If the messages window is open, then a check (✓) will appear in front of the command.

4.9 Help when you need it

An Online Help system is available to you for using **WAGO-I/O-*PRO* 32**. There you will find all the information that is also contained in this handbook.

4.9.1 'Help' 'Contents and Index'

With this command you can open the help topics window.

Under the **Contents** register card you will find the contents. The books can be opened and closed using a doubleclick or the corresponding button. Doubleclicking or activating the **Show** button on a highlighted topic will display the topic in the main window of help or in the index window.

Click on the **Index** register card to look for a specific word, and click on the **Search** register card to select a full-text search. Follow the instructions in the register cards.

X Help Topics Window

4.9.2 Main Help Window

In the main help window topics are displayed with index entries listed below them.

The following buttons available:

- **Help topics** opens the help topics window
- **Back** shows the help entry that was previously displayed
- **Print** opens the dialog box for printing
- << shows the help entry that comes prior in sequence to the present entry
- >> shows the help entry that is next in sequence

In addition you can use the following menu commands:

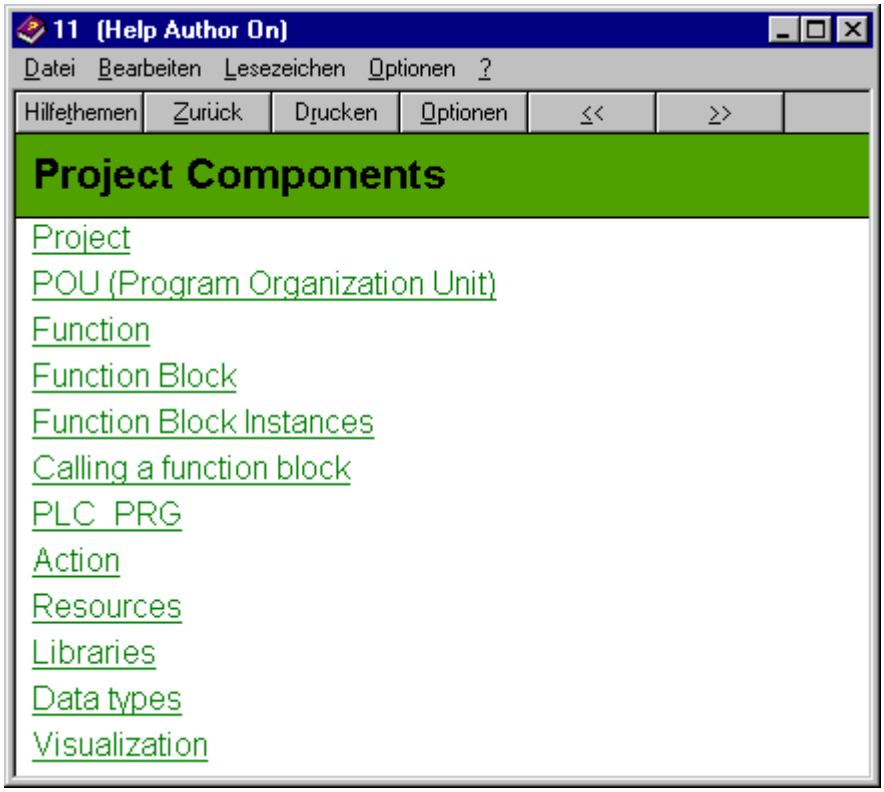
- With **'File' "Print Topics'** you can print out the present help entry.
- If you use the **'Edit' "Copy"** command, the selected text will be copied into the clipboard. From here you can insert the text into other applications and use it there.
- If you use the **'Edit' "Annotate"** command, a dialog box will be opened. There is an editing field on the left side of the dialog box in which you can enter an annotation to the help page.

On the right side there are buttons for **storing** the text, for canceling the program, for **deleting** the notation, for **copying** a highlighted text on the clipboard , and for **pasting** a text from the clipboard.

If you have made an annotation to a help entry, a small green paper clip will appear in the upper left-hand corner. By clicking the mouse on the paper clip, you can open the dialog box with the annotation that has been made.

- If you would like to mark a page from help, then you can set a bookmark. To do so, choose the **"Define" "Bookmark"** command. A dialog box will appear in which you can enter a new name (The name of the page can serve as a starter) or can delete an old bookmark. If bookmarks were defined, then these will be displayed in the **"Bookmark"** menu. By choosing these menu items, you can access the desired page.
- Under **"Options"**, you can define whether the help window always appears in the foreground or in the background or in the standard setting.
- With **"Display previous topics"** under **"Options"**, you are furnished with a selection window with the previously displayed help topics. Doubleclick the entry you wish to view.
- Under **"Options"**, you can select the desired **"Font" in small, normal**, or **large**.
- If **"Options" "Use System Color"** has been chosen, help will not be displayed in the colors that were set, but in the system colors instead.

X Main Help Window



4.9.3 Index Window

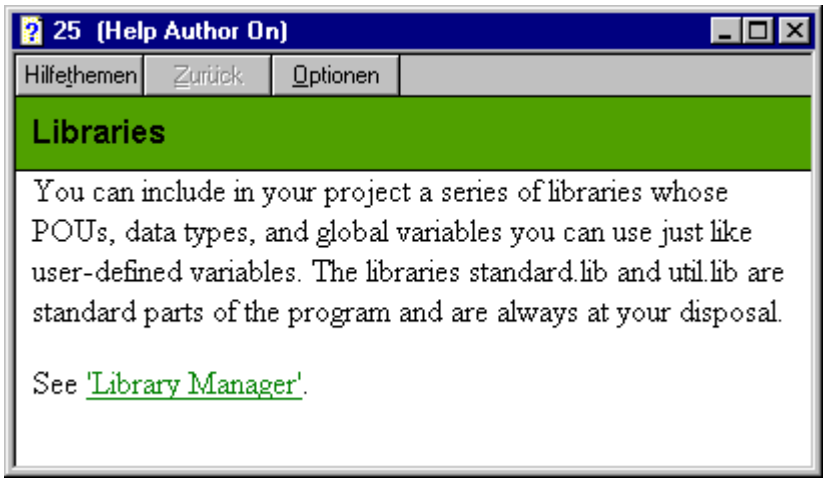
The index window contains explanations about the menu commands, terms, or sequences.

The index window will always remain on the surface by default, unless the help option is placed in the background in the main window of help.

The following buttons are available:

- **Help topics** opens the help topics window
- **Back** shows the help entry that was previously displayed
- **Print** opens the dialog box for printing
- << shows the help entry directly prior to the present entry
- >> shows the help entry that is next in sequence

X Index Window


25 (Help Author On)
Hilfethemen
Zurück
Optionen
Libraries
You can include in your project a series of libraries whose POUs, data types, and global variables you can use just like user-defined variables. The libraries standard.lib and util.lib are standard parts of the program and are always at your disposal.
See 'Library Manager'.

4.9.4 Context Sensitive Help

Shortcut: **<F1>**

You can use the **<F1>** key in an active window, in a dialog box, or above a menu command. When you perform a command from the menu, the help for the command called up at that time is displayed.

You can also highlight a text (for example, a key word or a standard function) and have the help displayed for that item.

5 The Editors

All editors for POUs (Program Organization Units) consist of a declaration part and a body. These are separated by a screen divider that can be dragged, as required, by clicking it with the mouse and moving it up or down. The body can consist of other a text or a graphic editor; the declaration portion is always a text editor.

5.1.1.1 Print margins

The vertical and horizontal margins that apply when the editor contents are printed, are shown by red dashed lines if the **'Show print range'** option in the project options in the dialog **'Workspace'** was selected. The properties of the printer that was entered apply, as well as the size of the print layout selected in the 'File' 'Printer Setup' menu. If no printer setup or no print layout is entered, a default configuration is used (Default.DFR and default printer). The horizontal margins are drawn as if the options 'New page for each object' or 'New page for each sub-object' were selected in 'Documentation settings'. The lowest margin is not displayed.

Note:
An exact display of the print margins is only possible when a zoom factor of 100% is selected.

5.1.1.2 Comment

User comments must be enclosed in the special symbol sequences "(*" and "*)". Example: (*This is a comment.*)

Comments are allowed in all text editors, at any location desired, that is in all declarations, the IL and ST languages and in self-defined data types. If the Project is printed out using a **template**, the comment that was entered during variable declaration appears in text-based program components after each variable.

In the FBD and LD graphic editors, comments can be entered for each network. To do this, search for the network on which you wish to comment and activate **'Insert' 'Comment'**. In CFC there are special comment POUs which can be placed at will.

In SFC, you can enter comments about a step in the dialog for editing step attributes.

Nested comments are also allowed if the appropriate option in the 'Project' 'Options' 'Build Options' dialog is activated.

In Online mode, if you rest the mouse cursor for a short time on a variable, the type and if applicable the address and comment of that variable are displayed in a tooltip.

5.1.1.3 Zoom to POU

Shortcut: <Alt>+<Enter>

With this command a selected POU is loaded into its editor. The command is available in the context menu (**<F2>**) or in the 'Extras' menu, if the cursor is positioned on the name of a POU in a text editor or if the POU box is selected in a graphic editor.

If you are dealing with a POU from a library, then the library manager is called up, and the corresponding POU is displayed.

5.1.1.4 Open instance

This command corresponds to the 'Project' 'Open instance' command.

This command corresponds to the command 'Project' 'Open instance'. It is available in the context menu (**<F2>**) or in the 'Extras' menu, if the cursor is positioned on the name of a function block in a text editor or if the function block box is selected in a graphic editor.

5.2 Declaration Editor

The declaration editor is used to declare variables of POUs and global variables, for data type declarations, and in the Watch and Receipt Manager. It gives access to the usual Windows functions, and even those of the IntelliMouse can be used if the corresponding driver is installed.

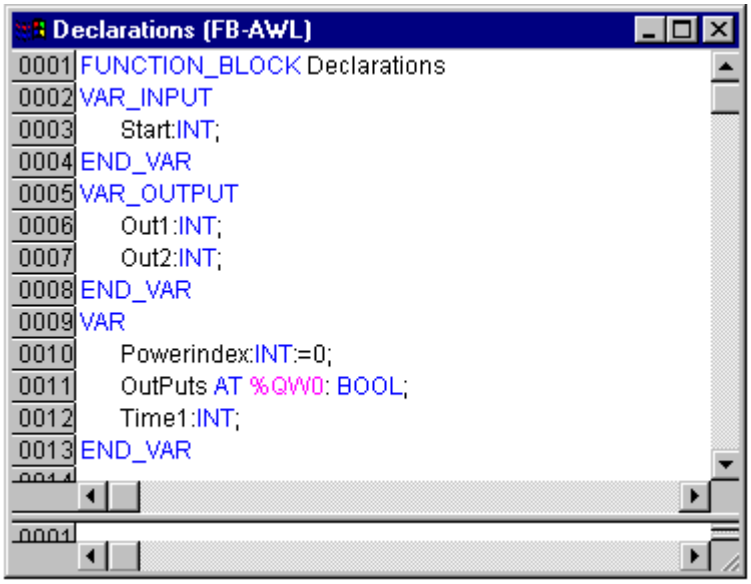
In Overwrite mode, **'OV'** is shown in black on the status bar; switching between Overwrite and Insert modes can be accomplished with the <Ins> key.

The declaration of variables is supported by syntax coloring.

The most important commands are found in the context menu (right mouse button or **<Ctrl>+<F10>**).

5.2.1 Declaration Part

All variables to be used only in this POU are declared in the declaration part of the POU. These can include: input variables, output variables, input/output variables, local variables, retain variables, and constants. The declaration syntax is based on the IEC61131-3 standard. An example of a correct declaration of variables in **WAGO-I/O-*PRO* 32**-Editor:



5.2.2 Input Variable

Between the key words **VAR_INPUT** and **END_VAR**, all variables are declared that serve as input variables for a POU. That means that at the call position, the value of the variables can be given along with a call.

Example:

```
VAR_INPUT

      in1:INT     (* 1. Inputvariable*)

END_VAR
```

5.2.3 Output Variable

Between the key words **VAR_OUTPUT** and **END_VAR**, all variables are declared that serve as output variables of a POU. That means that these values are carried back to the POU making the call. There they can be answered and used further.

Example:

```
VAR_OUTPUT

      out1:INT;   (* 1. Outputvariable*)

END_VAR
```

5.2.4 Input and Output Variables

Between the key words **VAR_IN_OUT** and **END_VAR**, all variables are declared that serve as input and output variables for a POU.

Attention:
With this variable, the value of the transferred variable is changed ("transferred as a pointer", Call-by-Reference). That means that the input value for such variables cannot be a constant. For this reason, even the VAR_IN_OUT variables of a function block can not be read or written directly from outside via <functionblockinstance><in/outputvariable>.

Example:

```
VAR_IN_OUT

      inout1:INT;      (* 1. Inputoutputvariable *)

END_VAR
```

5.2.5 Local Variables

Between the keywords **VAR** and **END_VAR**, all of the local variables of a POU are declared. These have no external connection; in other words, they can not be written from the outside.

Example:

```
VAR

      loc1:INT;  (* 1. Local Variable*)

END_VAR
```

5.2.6 Remanent variables

Remanent variables can retain their value throughout the usual program run period. These include Retain variables and Persistent variables.

Retain variables are identified by the keyword **RETAIN**. These variables maintain their value even after an uncontrolled shutdown of the controller, or a reset. When the program is run again, the stored values will be processed further. A practical example would be an operations timer that recommences timing after a power failure.

All other variables are newly initialized, either with their initialized values or with the standard initializations.

Persistent variables are identified by the keyword **PERSISTENT.** Unlike Retain variables, these variables retain their value even after a cold start, that is when the controller is shut down and restarted in an orderly fashion, or after a download. Persistent variables are not automatically Retain variables !

Example:

```
VAR RETAIN
```

```
      rem1:INT;  (* 1. Retain variable*)

END_VAR
```

5.2.7 Constants, Typed Literals

Constants are identified by the key word **CONSTANT**. They can be declared locally or globally.

Syntax:

```
VAR CONSTANT

      <Identifier>:<Type> := <initialization>;

END_VAR
```

Example:

```
VAR CONSTANT

      con1:INT:=12;    (* 1. Constant*)

END_VAR
```

A listing of possible constants can be found in the Chapter **Operands** of the Online Help chapters. See there also regarding the possibility of using typed constants (Typed Literals).

5.2.8 External variables

Global variables which are to be imported into the POU are designated with the keyword EXTERNAL. They also appear in the Watch window of the declaration part in Online mode.

If the VAR_EXTERNAL declaration does not match the global declaration in every respect, the following error message appears: "Declaration of '<var>' does not match global declaration!"

If the global variable does not exist, the following error message appears: "Unkown global variable: '<var>'!"

Example:

```
VAR EXTERNAL

      var_ext1:INT:=12;     (* 1st external variable *)

END_VAR
```

5.2.9 Keywords

Keywords are to be written in uppercase letters in all editors. Keywords may not be used as variables.

5.2.10 Variables declaration

A variables declaration has the following syntax:

<Identifier> {AT <Address>}**:**<Type> {**:=**<initialization>};

The parts in the braces {} are optional.

Regarding the identifier, that is the name of a variable, it should be noted that it may not contain spaces or umlaut characters, it may not be declared in duplicate and may not be identical to any keyword. Upper/lowercase writing of variables is ignored, in other words VAR1, Var1 and var1 are not different variables. Underlines in identifiers are meaningful, e.g. A_BCD and AB_CD are interpreted as different identifiers. Multiple consecutive underlines at the beginning of an identifier or within a identifier are not allowed. The length of the identifier, as well as the meaningful part of it, are unlimited.

All declarations of variables and data type elements can include initialization. They are brought about by the ":=" operator. For variables of elementary types, these initializations are constants. The default-initialization is 0 for all declarations.

Example:

```
var1:INT:=12;    (* Integer variable with initial value
     of 12*)
```

If you wish to link a variable directly to a definite address, then you must declare the variable with the keyword **AT**.

For faster input of the declarations, use the shortcut mode.

In function blocks you can also specify variables with incomplete address statements. In order for such a variable to be used in a local instance, there must be an entry for it in the variable configuration.

Pay attention to the possibility of an automatic declaration

An identifier is a sequence of letters, numbers, and underscores that begins with a letter or an underscore.

The variable identifier may not contain any blank spaces or special characters, may not be declared more than once and cannot be the same as any of the keywords. Capitalization is not recognized which means that VAR1, Var1, and var1 are all the same variable. The underscore character is recognized in identifiers (e.g., "A_BCD" and "AB_CD" are considered two different

identifiers). An identifier may not have more than one underscore character in a row. The first 32 characters are significant.

5.2.11 AT Declaration

If you wish to link a variable directly to a definite address, then you must declare the variable with the keyword **AT**. The advantage of such a procedure is that you can assign a meaningful name to an address, and that any necessary changes of an incoming or outgoing signal will only have to be made in one place (e.g., in the declaration).

Notice that variables requiring an input cannot be accessed by writing. A further restriction is that AT declarations can only be made for local and global variables, and not for input- and output variables from POUs.

Examples:

```
counter_heat7 AT %QX0.0: BOOL;

lightcabinetimpulse AT %IX7.2: BOOL;

download AT %MX2.2: BOOL;
```

Note:
If boolean variables are assigned to a Byte, Word or DWORD address, they occupy one byte with TRUE or FALSE, not just the first bit after the offset!

5.2.12 'Insert' 'Declarations keywords'

You can use this command to open a list of all the keywords that can be used in the declaration part of a POU. After a keyword has been chosen and the choice has been confirmed, the word will be inserted at the present cursor position.

You also receive the list, when you open the Input Assistant (<F2>) and choose the **Declarations** category.

5.2.13 'Insert' 'Type'

With this command you will receive a selection of the possible types for a declaration of variables. You also receive the list when you access the Input Assistant (<F2>).

The types are divided into these categories:

- **Standard types** BOOL, BYTE, etc.
- **Defined types** Structures, enumeration types, etc.
- **Standard function blocks** for instance declarations
- **Defined function blocks** for instance declarations

WAGO-I/O-*PRO* 32 supports all standard types of IEC1131-3:

Examples for the use of the various types are found in the Appendix F.

5.2.14 Syntax Coloring

In all editors you receive visual support in the implementation and declaration of variables. Errors are avoided, or discovered more quickly, because the text is displayed in color.

A comment left unclosed, thus annotating instructions, will be noticed immediately; keywords will not be accidentally misspelled, etc.

The following color highlighting will be used:

Blue	Keywords
Green	Comments in the text editors
Pink	Special constants (e.g. TRUE/FALSE, T#3s, %IX0.0)
Red	Input error (for example, invalid time constant, keyword, written in lower case,...)
Black	Variables, constants, assignment operators, ...

5.2.15 Shortcut Mode

The declaration editor for **WAGO-I/O-*PRO* 32** allows you to use the shortcut mode. This mode is activated when you end a line with <Ctrl><Enter>

The following shortcuts are supported:

- All identifiers up to the last identifier of a line will become declaration variable identifiers
- The type of declaration is determined by the last identifier of the line. In this context, the following will apply:

B or BOOL	gives the result	BOOL
I or INT	gives the result	INT
R or REAL	gives the result	REAL
S or string	gives the result	STRING

- If no type has been established through these rules, then the type is BOOL and the last identifier will not be used as a type (Example 1.).
- Every constant, depending on the type of declaration, will turn into an initialization or a string (Examples 2. and 3.).

- An address (as in %MD12) is extended around the ATATDeclaration>Proc... attribute(Example 4.).
- A text after a semicolon (;) becomes a comment (Example 4.).
- All other characters in the line are ignored (e.g., the exclamation point in Example 5.).

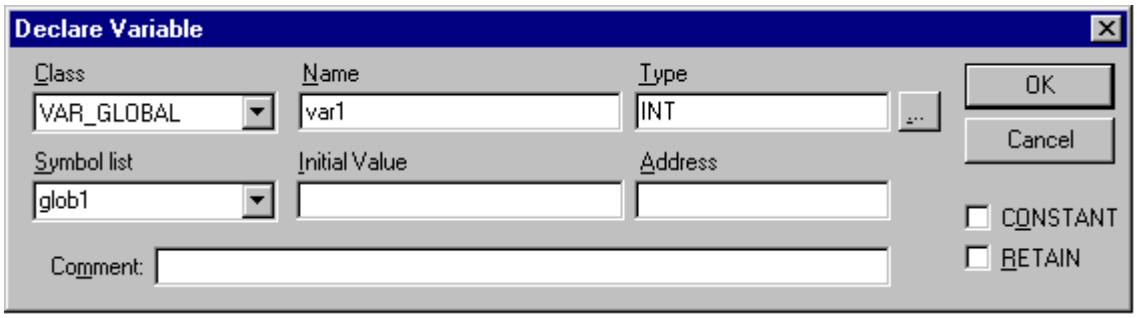
Examples:

Shortcut	Declaration
A	A: BOOL;
A B I 2	A, B: INT := 2;
ST S 2; A string	ST:STRING(2); (* A string *)
X %MD12 R 5 Real Number	X AT %MD12: REAL := 5.0;(* Real Number *)
B !	B: BOOL;

5.2.16 Autodeclaration

If the Autodeclaration option has been chosen in the Editor category of the Options dialog box , then a dialog box will appear in all editors after the input of a variable that has not yet been declared. With the help of this dialog box, the variable can now be declared.

X Dialog Box for Declaration of Variables



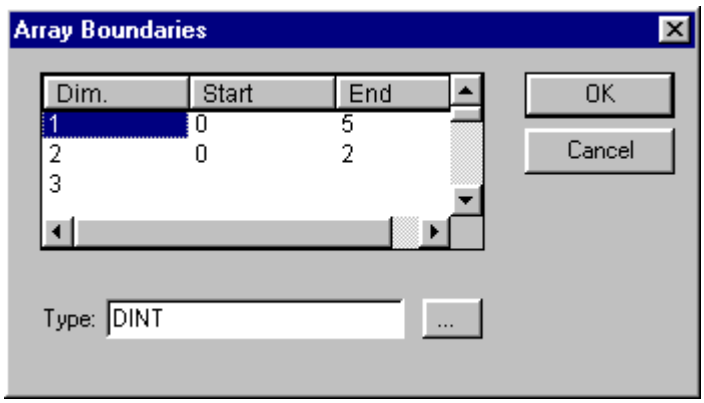
With the help of the **Class** combobox, select whether you are dealing with a local variable (**VAR**), input variable((**VAR_INPUT**), output variable (**VAR_OUTPUT**), input/output variable (**VAR_INOUT**), or a global variable (**VAR_GLOBAL**).

With the **CONSTANT** and **RETAIN** options, you can define whether you are dealing with a constant or a retain variable

The variable name you entered in the editor has been entered in the **Name** field, BOOL has been placed in the **Type** field. The ... button opens the Input Assistant dialog which allows you to select from all possible data types.

If ARRAY is chosen as the variable type, the dialog for entering array boundaries appears.

X Dialog for determining array boundaries during automatic declaration



For each of the three possible dimensions (**Dim.**), array boundaries can be entered under **Start** and **End** by clicking with the mouse on the corresponding field to open an editing space. The array data type is entered in the **Type** field. In doing this, the ... button can be used to call up an input assistant dialog.

Upon leaving the array boundaries dialog via the **OK** button, variable declarations in IEC format are set up based on the entries in the Type field in the dialog. Example: ARRAY [1..5, 1..3] OF INT

In the field **Initial value**, you may enter the initial value of the variable being declared. If this is an array or a valid structure, you can open a special initialization dialog via the ... button or <F2>, or open the input assistant dialog for other variable types.

In the initialization dialog for an array you are presented a list of array elements; a mouse click on the space following ":="opens an editing field for entering the initial value of an element.

In the initialization dialog for a structure, individual components are displayed in a tree structure. The type and default initial value appear in brackets after the variable name; each is followed by ":=". A mouse click on the field following ":=" opens an editing field in which you can enter the desired initial value. If the component is an array, then the display of individual fields in the array can be expanded by a mouse click on the plus sign before the array name and the fields can be edited with initial values.

After leaving the initialization dialog with **OK**, the initialization of the array or the structure appears in the field **Initial value** of the declaration dialog in IEC format.

Example:

```
x:=5,field:=2,3,struct2:=(a:=2,b:=3)
```

In the **Address** field, you can bind the variable being declared to an IEC address (AT declaration).

If applicable, enter a **Comment**. The comment can be formatted with line breaks by using the key combination **<Ctrl>** + **<Enter>**.

By pressing **OK**, the declaration dialog is closed and the variable is entered in the corresponding declaration editor in accordance to the IEC syntax.

Note:
The dialog box for variable declaration you also get by the command 'Edit' 'Declare Variable'. If the cursor is resting on a variable in Online mode, the Autodeclare window can be opened with **<Shift><F2>** with the current variable-related settings displayed.

5.2.17 Line Numbers in the Declaration Editor

In offline mode, a simple click on a special line number will mark the entire text line.

In the online mode, a single click on a specific line number will open up or close the variable in this line, in case a structural variable is involved.

5.2.18 Declarations as tables

If the **Declarations as table** option is activated in the Options dialog box in the category, the declaration editor looks like a table. As in a card-index box, you can select the register cards of the respective variable types and edit the variables.

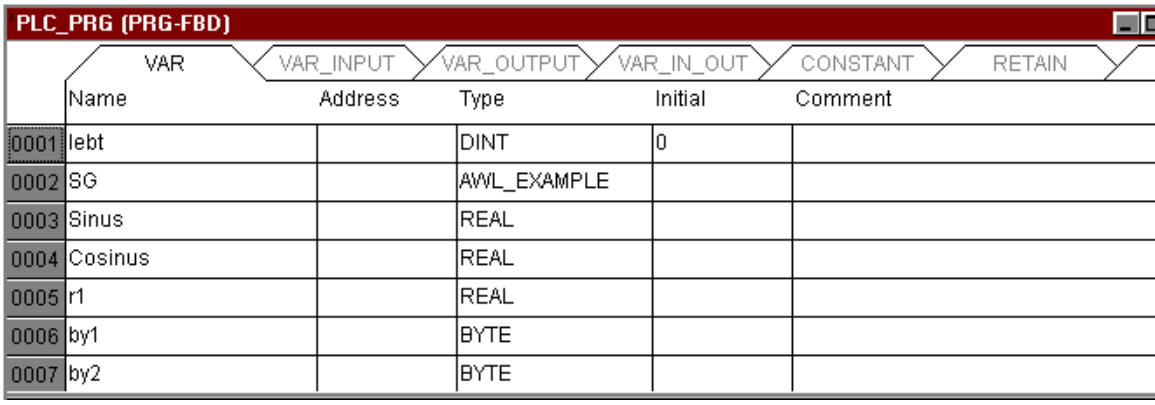
For each variable you are given the following entry fields.

Name:	Input the identifier of the variable.
Address:	If necessary, input the address of the variable (AT declaration)
Type:	Input the type of the variable. (Input the function block when instantiating a function block)
Initial:	Enter a possible initialization of the variable (corresponding to the ":= " assignment operator).
Comment:	Enter a comment here.

Both of the display types of the declaration editor can be changed without causing any problems. In the online mode, there are no differences for the display.

In order to edit a new variable, select the 'Insert' 'New Declaration' command.

X Declaration Editor as a Table



5.2.19 'Insert' 'New Declaration'

With this command you bring a new variable into the declaration table of the declaration editor. If the present cursor position is located in an field of the table, then the new variable will be pasted in the preceding line; otherwise, the new variable is pasted at the end of the table. Moreover, you can paste a new declaration at the end of the table by using the right arrow key or the tab key in the last field of the table.

You will receive a variable that has "Name" located in the **Name** field, and "Bool" located in the **Type** field, as its default setting. You should change these values to the desired values. Name and type are all that is necessary for a complete declaration of variables.

5.2.20 Pragma instructiion

The pragma instruction is used to affect the properties of a variable concerning the compilation process. It can be used in with supplementary text in a program line of the declaration editor or in its own line.

The pragma instruction is enclosed in curly brackets, upper- and lower-case are ignored: { <Instruction text> }

If the compiler cannot meaningfully interpret the instruction text, the entire pragma is handled as a comment and read over. A warning is issued, however: "Ignore compiler directive ‚<Instruction text>'!"

Depending on the type and contents of pragma, the pragma either operates on the line in which it is located or on all subsequent lines until it is ended by an appropriate pragma, or the same pragma is executed with different parameters, or the end of the file is reached. By file we mean here: declaration part, implementation portion, global variable list, type declaration.

The opening bracket may immediately follow a variable name. Opening and closing brackets must be located on the same line.

The following pragma may currently be used:

{flag [<flags>] [off|on]}

<flags> can be a combination of the following flags:

noinit:	The variable will not be initialized.
nowatch:	The variable can not be monitored
noread:	The variable is exported to the symbol file without read permission
nowrite:	The variable is exported to the symbol file without write permission
noread, nowrite:	Die Variable wird nicht in die Symboldatei exportiert

With the "**on**" modifier, the pragma operates on all subsequent variable declarations until it is ended by the pragma {flag **off**}, or until overwritten by another {flag <flags> on} pragma.

Without the "on" or "off" modifier, the pragma operates only on the current variable declaration (that is the declaration that is closed by the next semicolon).

Examples:

The variable a will not be initialized and will not be monitored. The variable b will not be initialized:

```
VAR
      a : INT    {flag noinit, nowatch};
      b : INT  {flag noinit };

END_VAR

VAR
      {flag noinit, nowatch on}
      a : INT;
      {flag noinit on}
      b : INT;
      {flag off}

END_VAR
```

Neither variable will be initialized:

```
{flag noinit on}

VAR
      a : INT;
      b : INT;

END_VAR
```

```
{flag off}

VAR
      {flag noinit on}
      a : INT;

b : INT;

{flag off}

END_VAR
```

The flags "**noread**" and "**nowrite**" are used, in a POU that has read and/or write permission, to provide selected variables with restricted access rights. The default for the variable is the same as the setting for the POU in which the variable is declared. If a variable has neither read nor write permission, it will not be exported into the symbol file.

Examples:

If the POU has read and write permission, then with the following pragmas variable a can only be exported with write permission, while variable b can not be exported at all:

```
VAR
      a : INT    {flag noread};
      b : INT {flag noread, nowrite};

END_VAR

VAR
      { flag noread on}
      a : INT;
      { flag noread, nowrite on}
      b : INT;
      {flag off}

END_VAR
```

Neither variable a nor b will be exported to the symbol file:

```
{ flag noread, nowrite on }

VAR
      a : INT;
      b : INT;
      END_VAR

{flag off}

VAR
      { flag noread, nowrite on}
      a : INT;
```

```
      b : INT;
      {flag off}

END_VAR
```

The pragma operates **additively** on all subsequent variable declarations.

Example: (all POUs in use will be exported with read and write permission)

```
a : afb;

...

FUNCTION_BLOCK afB
      VAR
      b : bfb {flag nowrite};
      c : INT;
      END_VAR

...

FUNCTION_BLOCK bfB
      VAR
      d : INT {flag noread};
      e : INT {flag nowrite};
      END_VAR
```

"a.b.d": Will not be exported

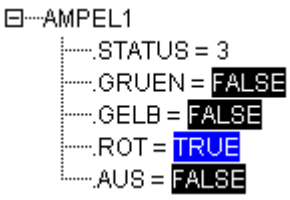
"a.b.e": Will be exported only with read permission

"a.c": Will be exported with read and write permission.

5.2.21 Declaration Editors in Online Mode

In online mode , the declaration editor changes into a monitor window. In each line there is a variable followed by the equal sign (=) and the value of the variable. If the variable at this point is undefined, three question marks (???) will appear. For function blocks, values are displayed only for open instances (command: 'Project' 'Open instance').

In front of every multi-element variable there is a plus sign. By pressing <Enter> or after doubleclicking on such a variable, the variable is opened up. In the example, the traffic signal structure would be opened up.



When a variable is open, all of its components are listed after it. A minus sign appears in front of the variable. If you doubleclick again or press <Enter>, the variable will be closed, and the plus sign will reappear.

Pressing <Enter> or doubleclicking on a single-element variable will open the dialog box to write a variable. Here it is possible to change the present value of the variable. In the case of Boolean variables, no dialog box appears; these variables are toggled.

The new value is displayed after the variable, in pointed brackets and in turquoise color, and remains unchanged. If the 'Online' 'Write values' command is given, then all variables are placed in the selected list and are once again displayed in black.

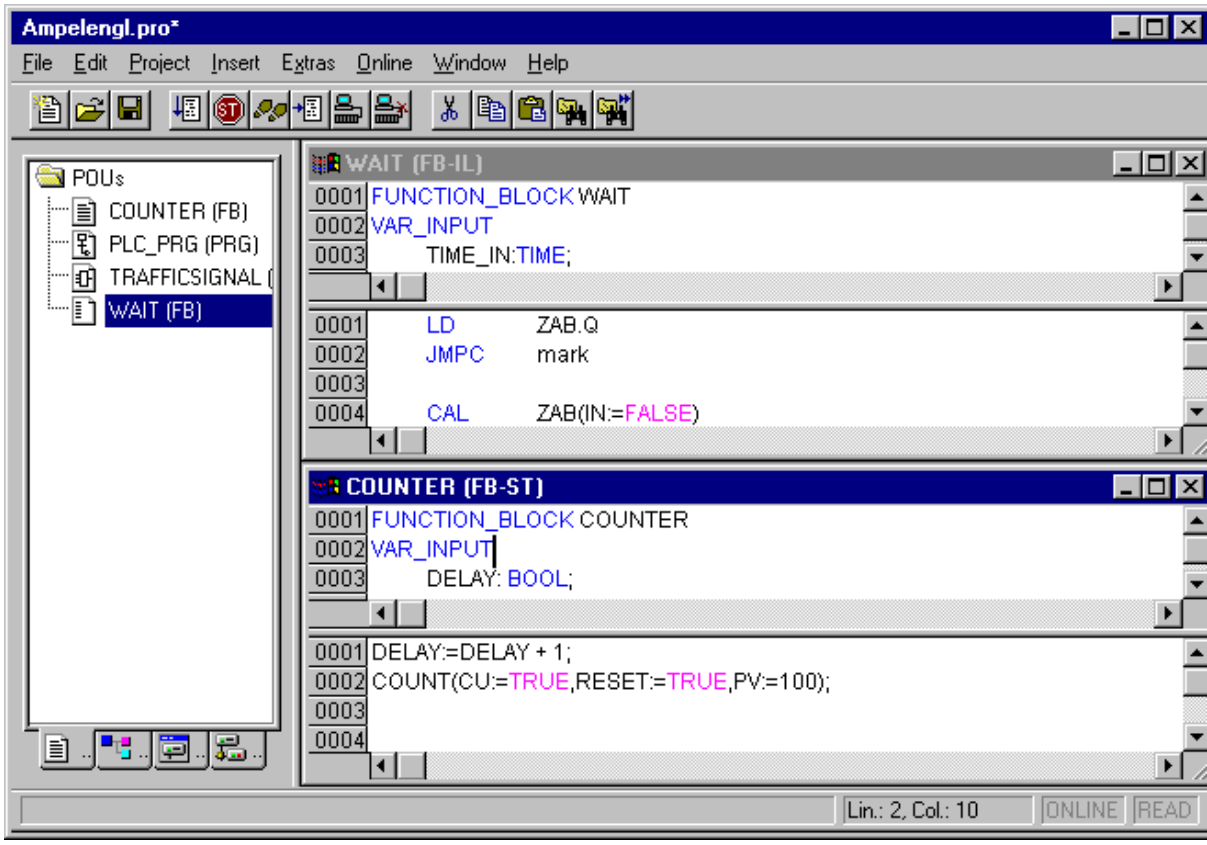
If the 'Online' 'Force values' command is given, then all variables will be set to the selected values, until the 'Release force' command is given. In this event, the color of the force value changes to red

5.3 The Text Editors

The text editors used for the implementation portion (the Instruction List editor and the Structured Text editor) of **WAGO-I/O-*PRO* 32** provide the usual Windows text editor functions.

The implementation in the text editors is supported by syntax coloring.

In Overwrite mode the status bar shows a black **OV**. You can switch between Overwrite mode and Insert mode by key **<Ins>**



The most important commands are found in the context menu (right mouse button or **<Ctrl>+<F10>**).

The text editors use the following menu commands in special ways:

5.3.1.1 'Insert''Operators'in text editors

With this command all of the operators available in the current language are displayed in a dialog box.

If one of the operators is selected and the list is closed with **OK**, then the highlighted operator will be inserted at the present cursor position. (This is managed here just as it is in the Input Assistant).

5.3.1.2 'Insert''Operand'in text editors

With this command all variables in a dialog box are displayed. You can select whether you would like to display a list of the global, the local, or the system variables.

If one of the operands is chosen, and the dialog box is closed with **OK**, then the highlighted operand will be inserted at the present cursor position. (This is managed here just as it is in the Input Assistant).

5.3.1.3 'Insert"Function' in text editors

With this command all functions will be displayed in a dialog box. You can choose whether to have a list displaying user-defined or standard functions.

If one of the functions is selected and the dialog box is closed with **OK**, then the highlighted function will be inserted at the current cursor position. (The management will proceed, as in the input selection.)

If the **With arguments** option was selected in the dialog box, then the necessary input and output variables will also be inserted.

5.3.1.4 'Insert"Function Block' in text editors

With this command all function blocks are displayed in a dialog box. You can choose whether to have a list displaying user-defined or standard function blocks.

If one of the function blocks is selected and the dialog box is closed with **OK**, then the highlighted function block will be inserted at the current cursor position. (This is managed here just as it is in the Input Assistant).

If the **With arguments** option was selected in the dialog box, then the necessary input variables of the function block will also be inserted.

5.3.1.5 Calling POUs with output parameters in text editors

The output parameters of a called POU can be directly assigned upon being called in the text languages IL and ST. Example: Output parameter out1 of afbinst is assigned variable a.

IL:

```
CAL afbinst(in1:=1, out1=>a)
```

ST:

```
afbinst(in1:=1, out1=>a);
```

5.3.1.6 The text editors in Online mode

The online functions in the editors are set breakpoint and single step processing (steps). Together with the monitoring, the user thus has the debugging capability of a modern Windows standard language debugger.

In Online mode, the text editor window is vertically divided in halves. On the left side of the window you will then find the normal program text; on the right side you will see a display of the variables whose values were changed in the respective lines.

The display is the same as in the declaration part. That means that when the PLC is running, the present values of the respective variables will be displayed.

The following should be noted when monitoring expressions or Bit-addressed variables: in the case of expressions, the value of the entire expression is always displayed. Example: a AND b is displayed in blue or with ":=TRUE" if both a and b are TRUE. For Bit-addressed variables, the bit value that is addressed is always monitored (e.g. a.3 is displayed in blue or with ":=TRUE, if a has the value 4).

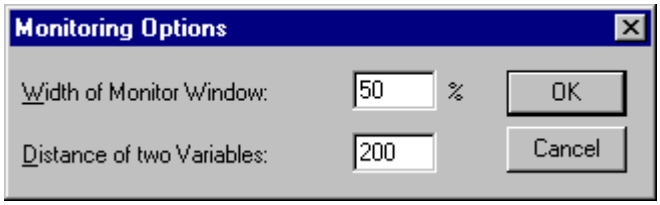
If you place the mouse pointer briefly above a variable, then the type, the address and the comment about the variable will be displayed in a Tooltip.

5.3.1.7 'Extras' 'Monitoring Options'

With this command you can configure your monitoring window. In the text editors, the window is divided into two halves during monitoring. The program is located in the left half. In the right half, all variables that are located in the corresponding program line are monitored.

You can specify the Monitor Window **Width** and which **Distance** two variables should have in a line. An distance declaration of 1 corresponds, in this case, to a line height in the selected font.

X Monitoring Options Dialog Box



5.3.1.8 Breakpoint Positions in Text Editor

Since in **WAGO-I/O-*PRO* 32** several IL lines are internally combined into a single C-code line, breakpoints can not be set in every line. Breakpoint positions include all positions in a program at which values of variables can change or where the program flow branches off. (Exception: function calls. If necessary, a breakpoint in the function must be set here.) At the positions lying inbetween, a breakpoint would not even make sense, since nothing has been able to change in the data since the preceding breakpoint position.

This results in the following breakpoint positions in the IL:

- At the start of the POU
- At every LD, LDN (or, in case a LD is located at a label, then at the label)
- At every JMP, JMPC, JMPCN
- At every label
- At every CAL, CALC, CALCN

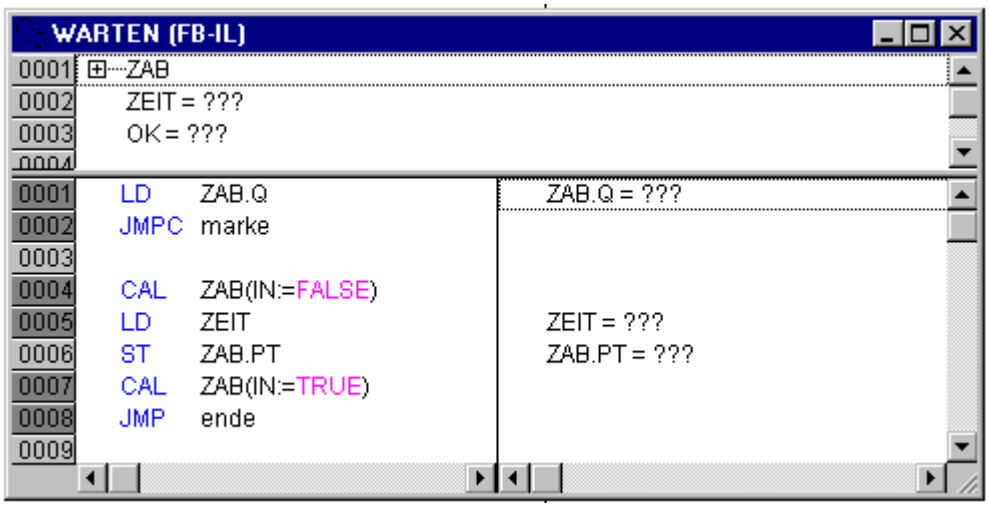
- At every RET, RETC, RETCN
- At the end of the POU

Structured Text accommodates the following breakpoint positions:

- At every assignment
- At every RETURN and EXIT instruction
- in lines where conditions are being evaluated (WHILE, IF, REPEAT)
- At the end of the POU

Breakpoint positions are marked by the display of the line number field in the color which is set in the project options.

X IL Editor with Possible Breakpoint Positions (darker number fields)



5.3.1.9 How do you set a breakpoint?

In order to set a breakpoint, click the line number field of the line where you want to set a breakpoint. If the selected field is a breakpoint position, then the color of the line numbers field will change from dark gray to light blue, and the breakpoint will be activated in the PLC.

5.3.1.10 Deleting Breakpoints

Correspondingly, in order to delete a breakpoint, click on the line number field of the line with the breakpoint to be deleted.

Setting and deleting of breakpoints can also be selected via the menu ('Online' 'Toggle Breakpoint'), via the function key <F9>, or via the symbol in the tool bar.

5.3.1.11 What happens at a breakpoint?

If a breakpoint is reached in the PLC, then the screen will display the break with the corresponding line. The line number field of the line where the PLC is positioned will appear in red. The user program is stopped in the PLC.

If the program is at a breakpoint, then the processing can be resumed with 'Online' 'Run'.

In addition, with 'Online' 'Step over' or 'Step in' you can cause the program to run to the next breakpoint position. If the instruction where you are located is a CAL command, or, if there is a function call in the lines up to the next breakpoint position, then you can use **'Step over'** to bypass the function call. With **'Step in'**, you will branch to the open POU

5.3.1.12 Line Number of the Text Editor

The line numbers of the text editor give the number of each text line of an implementation of a POU.

In Off-line mode, a simple click on a special line number will mark the entire text line.

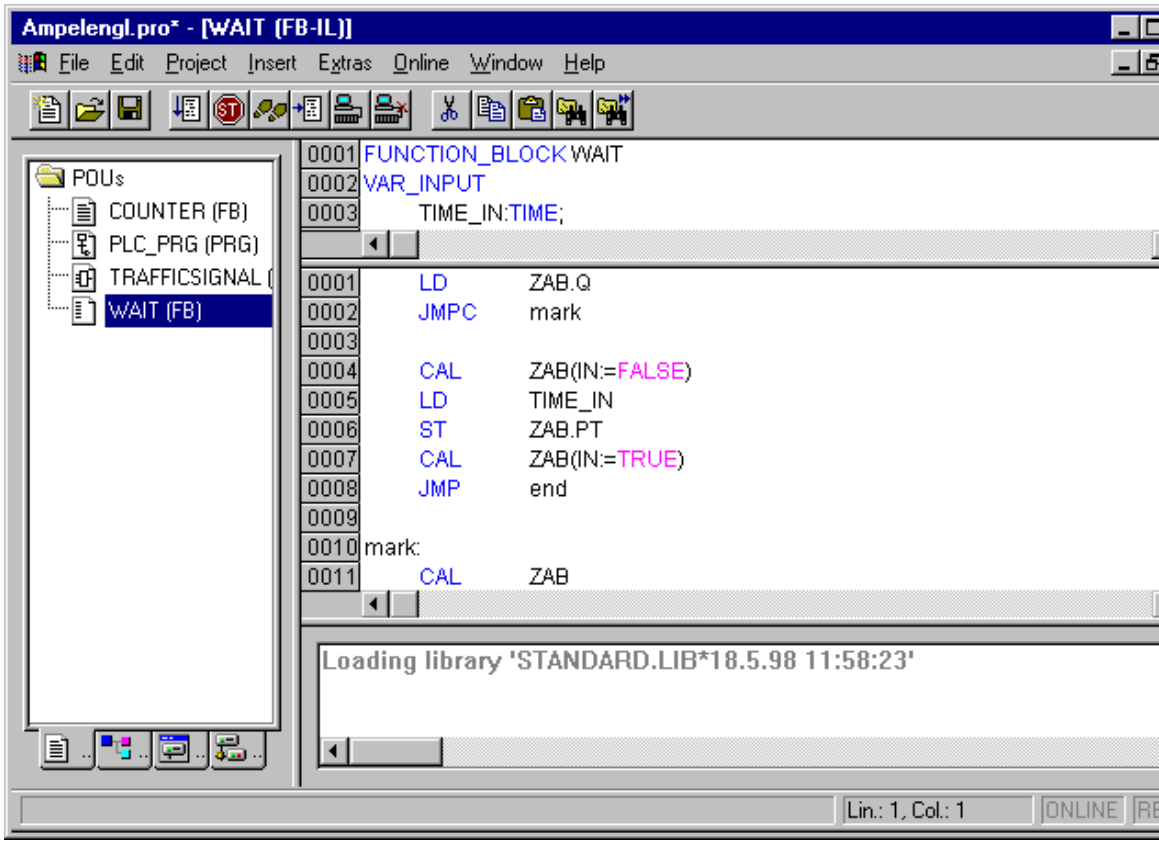
In Online mode, the background color of the line number indicates the breakpoint status of every line. The standard settings for the colors are

- dark gray: This line is a possible position for a breakpoint.
- light blue: a breakpoint has been set in this line.
- red: The program has reached this point.

In Online mode, simply clicking the mouse will change the breakpoint status of this line.

5.3.2 The Instruction List Editor

This is how a POU written in the IL looks under the corresponding **WAGO-I/O-*PRO* 32** editor:



All editors for POUs consist of a declaration part and a body. These are separated by a screen divider.

The Instruction List editor is a text editor with the usual capabilities of Windows text editors. The most important commands are found in the context menu (right mouse button or <Ctrl>+<F10>).Multiline POU calls are also possible: Example:

```
CAL CTU_inst(
          CU:=%IX10,
               PV:=(
               LD    A
              ADD   5
               )
      )
```

For information concerning the language, see Instruction List (IL).

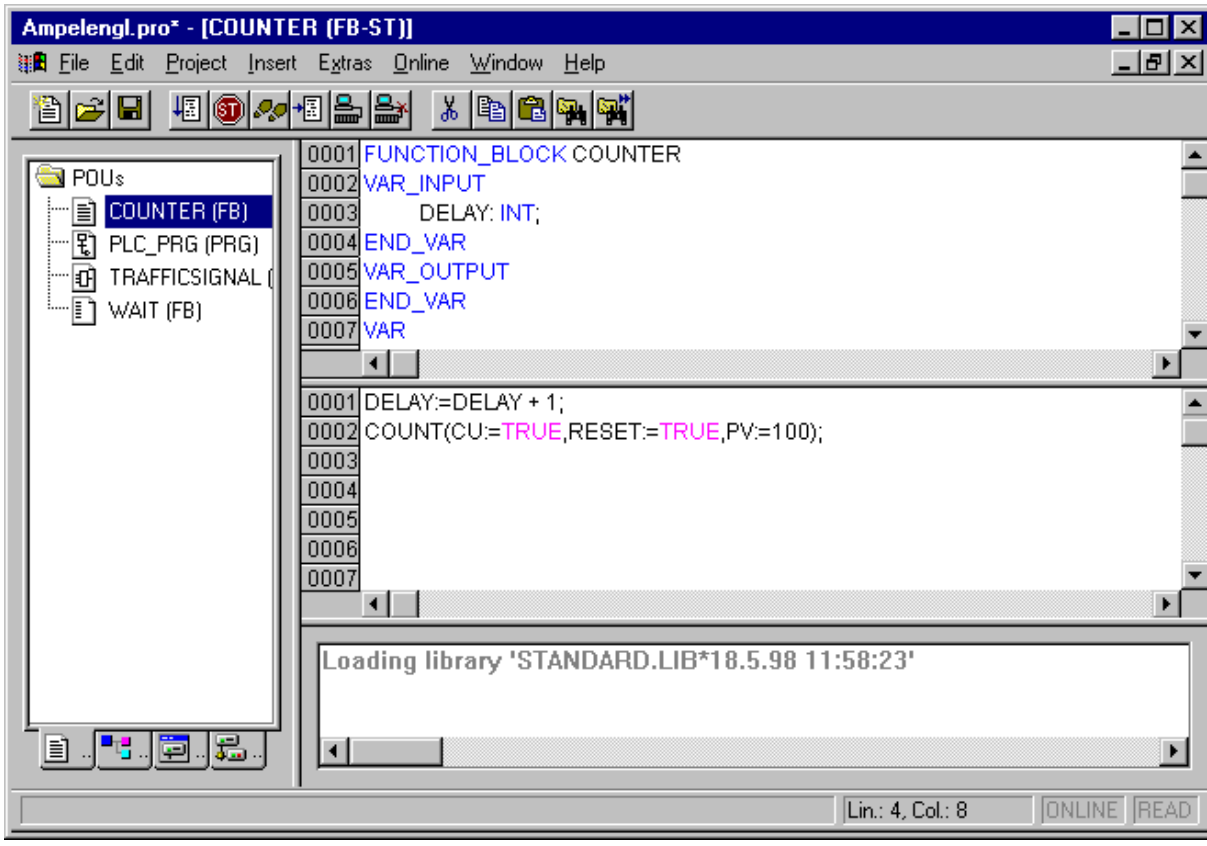
5.3.2.1 IL in Online mode

With the 'Online' 'Flow control' command, an additional field in which the accumulator contents is displayed is inserted in the IL editor on the left side of every line.

For further information concerning the IL editor in Online mode, see 'The Text Editors in Online Mode'.

5.3.3 The Editor for Structured Text

This is how a POU written in ST appears under the corresponding **WAGO-I/O-*PRO* 32** editor:



All editors for POUs consist of a declaration part and a body. These are separated by a screen divider.

The editor for Structured Text is a text editor with the usual capabilities of Windows text editors. The most important commands are found in the context menu (right mouse button or **<Ctrl>+<F10>**).

See also:

For information about the language, see 'Structured Text (ST).

5.4 The Graphic Editors

The editors of the graphically oriented languages, sequential function chart SFC, ladder diagram LD and function block diagram FBD and of free graphic function block diagrams have many points in common. In the following paragraphs these features will be summarized; the specific descriptions of LD, FBD an CFC, as well as the Sequential Function Chart language SFC follow in separate sections. The implementation in the graphics editors is supported by syntax coloring.

5.4.1.1 Zoom

Objects such as POUs, actions, transitions etc. in the languages SFC, LD, FBD, CFC and in visualizations can be enlarged or reduced in size with a zoom function. All elements of the window contents of the implementation part are affected; the declaration part remains unchanged.

In standard form, every object is displayed with the zoom level 100%. The zoom level that is set is saved as an object property in the project.

The printing of project documentation always occurs at the 100% display level!

The zoom level can be set through a selection list in the toolbar. Values between 25% and 400% can be selected; individual values between 10% and 500% can be entered manually.

The selection of a zoom level is only available if the cursor rests on an object created in a graphical language or a visualization object.

Even with the object zoomed, cursor positions in the editors can be further selected and even reached with the arrow keys. Text size is governed by the zoom factor and the font size that is set.

The execution of all editor menu features (e.g. inserting a box) as a function of cursor position is available at all zoom levels, taking the same into account.

In Online mode, each object is displayed according to the zoom level that has been set; Online functionality is available without restriction.

When the IntelliMouse is used, an object can be enlarged/reduced by pressing the **<CTRL>** key and at the same time turning the wheel forward or backwards.

5.4.1.2 Network

In the LD and FBD editors, the program is arranged in a list of networks. Each network is designated on the left side by a serial network number and has a structure consisting of either a logical or an arithmetic expression, a program, function or function block call, and a jump or a return instruction.

5.4.1.3 Label

Each network has a label that can optionally be left empty. This label is edited by clicking the first line of the network, directly next to the network number. Now you can enter a label, followed by a colon.

5.4.1.4 Network Comments,'Extras' 'Options'

Every network can be supplied with a multi-lined comment. In **'Extras' 'Options'**, you can enter the maximum number of lines to be made available

for a network comment. This entry is made in the **maximum comment size** field. (The default value here is 4.) You can also enter the number of lines that generally should be reserved for comments (**minimum comment size**). If, for example, the number 2 is entered, then, at the start of each network there will be two empty lines after the label line. The default value here is 0, which has the advantage of allowing more networks to fit in the screen area.

If the minimal comment size is greater than 0, then in order to enter a comment you simply click in the comment line and then enter the comment. Otherwise you must next select the network to which a comment is to be entered, and use **'Insert' 'Comment'** to insert a comment line. In contrast to the program text, comments are displayed in gray.

5.4.1.5 'Insert' 'Network (after)' or 'Insert' "Network (before)"

Shortcut: <Shift>+<T>

In order to insert a new network in the FBD or the LD editor, select the 'Insert' 'Network (after)' or the 'Insert' 'Network (before)' command, depending on whether you want to insert the new network before or after the present network. The present network can be changed by clicking the network number. You will recognize it in the dotted rectangle under the number. With the **<Shift key>** and a mouse click you can select from the entire area of networks, from the present one to the one clicked.

5.4.1.6 The network editors in the online mode

In the FBD and the LD editors you can only set breakpoints for networks. The network number field of a network for which a breakpoint has been set, is displayed in blue. The processing then stops in front of the network, where the breakpoint is located. In this case, the network number field is displayed in red. With single step processing (steps), you can jump from network to network.

All values are monitored upon entering and exiting network POUs (Program Organization Units).

The following should be noted when monitoring expressions or Bit-addressed variables: In expressions, e.g. a AND b, used as transition condition or function block input, the value of the whole expression is always displayed (a AND b is shown in blue or as :=TRUE, if a and b are TRUE). For Bit-addressed variables, the bit value that is addressed is always monitored (e.g. a.3 is displayed in blue or with ":=TRUE, if a has the value 4)

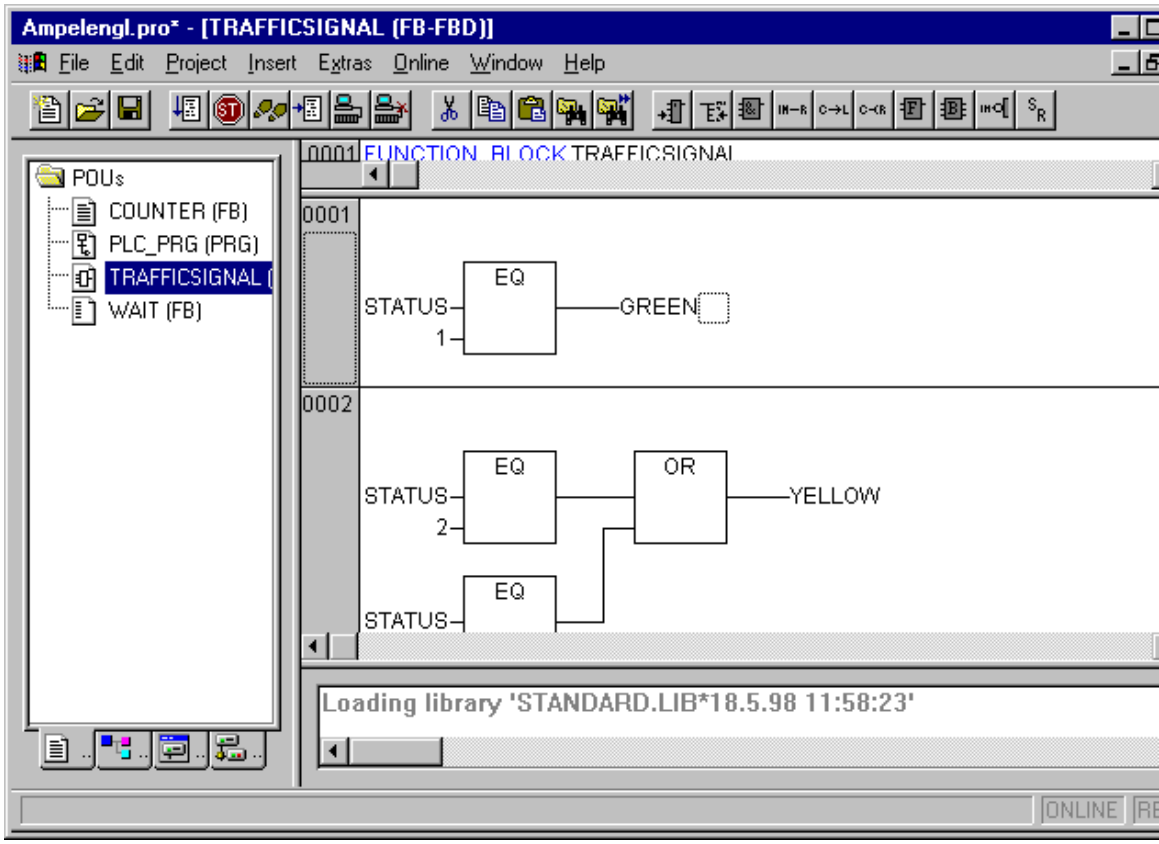
The flow control is run with the 'Online' 'Flow control' command. Using the flow control, you can view the present values that are being carried in the networks over the connecting lines. If the connecting lines do not carry Boolean values, then the value will be displayed in a specially inserted field. The monitor fields for variables that are not used (e.g. in the function SEL) are displayed in a shade of grey. If the lines carry Boolean values, then they will

be shaded blue, in the event that they carry TRUE. Therefore, you can accompany the flow of information while the PLC is running.

If you place the mouse pointer briefly above a variable, then the type, the address and the comment about the variable will be displayed in a Tooltip.

5.4.2 The Function Block Diagram Editor

This is how a POU written in the FBD under the corresponding **WAGO-I/O-*PRO* 32** editor looks:



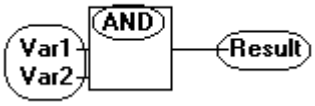
The Function Block Diagram editor is a graphic editor. It works with a list of networks, in which every network contains a structure that displays, respectively, a logical or an arithmetical expression, the calling up of a function block, a function, a program, a jump, or a return instruction.The most important commands are found in the context menu (right mouse button or <Ctrl>+<F10>).

5.4.2.1 Cursor positions in FBD

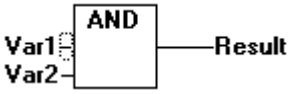
Every text is a possible cursor position. The selected text is on a blue background and can now be changed.

You can also recognize the present cursor position by a dotted rectangle. The following is a list of all possible cursor positions with an example:

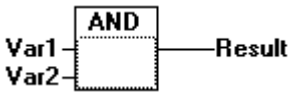
1) Every text field (possible cursor positions framed in black):



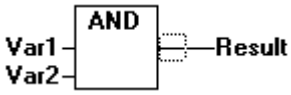
2) Every input:



3) Every operator, function, or function block:

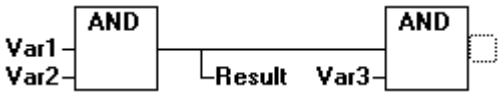


4) Outputs, if an assignment or a jump comes afterward:

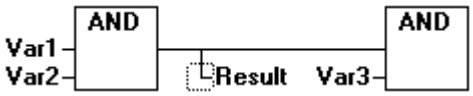


5) The lined cross above an assignment, a jump, or a return instruction:

6) Behind the outermost object on the right of every network ("last cursor position," the same cursor position that was used to select a network):



7) The lined cross directly in front of an assignment:



5.4.2.2 How to set the cursor in FBD

The cursor can be set at a certain position by clicking the mouse, or with the help of the keyboard.

Using the arrow keys, you can jump to the nearest cursor position in the selected direction at any time. All cursor positions, including the text fields, can be accessed this way. If the last cursor position is selected, then the <up> or <down> arrow keys can be used to select the last cursor position of the previous or subsequent network.

An empty network contains only three question marks "???". By clicking behind these, the last cursor position is selected.

5.4.2.3 'Insert' 'Assign' in FBD

Symbol: **Shortcut: <Ctrl>+<A>**

This command inserts an assignment.

Depending on the selected position (see 'Cursor positions in FBD'), insertion takes place directly in front of the selected input (Cursor Position 2), directly after the selected output (Cursor Position 4) or at the end of the network (Cursor Position 6).

For an inserted assignment, a selection can be made accompanying the entered text "???", and the assignment can be replaced by the variable that is to be assigned. For this you can also use the Input Assistant.

In order to insert an additional assignment to an existing assignment, use the 'Insert' 'Output' command.

5.4.2.4 'Insert' 'Jump' in FBD

Symbol: **Shortcut: <Ctrl>+<L>**

This command inserts a jump.

Depending on the selected position (see 'Cursor positions in FBD'), insertion takes place directly in front of the selected input (Cursor Position 2), directly after the selected output (Cursor Position 4) or at the end of the network (Cursor Position 6).

For an inserted jump, a selection can be made accompanying the entered text "???", and the jump can be replaced by the label to which it is to be assigned.

5.4.2.5 'Insert' 'Return' in FBD

Symbol: **Shortcut: <Ctrl>+<R>**

This command inserts a RETURN instruction.

Depending on the selected position (see 'Cursor positions in FBD'), insertion takes place directly in front of the selected input (Cursor Position 2),directly after the selected output (Cursor Position 4), directly before the selected line cross (Cursor Position 5), or at the end of the network (Cursor Position 6)

5.4.2.6 'Insert' 'Box' in FBD

Symbol: **Shortcut: <Ctrl>+<B>**

With this command, operators, functions, function blocks and programs can be inserted. First of all, it is always inserted an "AND" operator. This can be converted by Selection and Overwrite of the type text ("AND") into every other operator, into every function, into every function block and every program. You can select the desired POU by using Input Assistant (<F2>). If the new selected block has another minimum number of inputs, these will be attached. If the new block has a smaller highest number of inputs, the last inputs will be deleted.

In functions and function blocks, the formal names of the in- and outputs are displayed.

In function blocks there exists an editable instance field above the box. If another function block that is not known is called by changing the type text, an operator box with two inputs and the given type is displayed. If the instance field is selected, Input Assistant can be obtained via <F2> with the categories for variable selection.

The newest POU is inserted at the selected position:

- If an input is selected (Cursor Position 2), then the POU is inserted in front of this input. The first input of this POU is linked to the branch on the left of the selected input. The output of the new POU is linked to the selected input.
- • If an output is selected (Cursor Position 4), then the POU is inserted after this output. The first input of the POU is connected with the selected output. The output of the new POU is linked to the branch with which the selected output was linked.
- If a POU, a function, or a function block is selected (Cursor Position 3), then the old element will be replaced by the new POU.
- As far as possible, the branches will be connected the same way as they were before the replacement. If the old element had more inputs than the new one, then the unattachable branches will be deleted. The same holds true for the outputs.
- If a jump or a return is selected, then the POU will be inserted before this jump or return. The first input of the POU is connected with the branch to the left of the selected element. The output of the POU is linked to the branch to the right of the selected element.
- If the last cursor position of a network is selected (Cursor Position 6), then the POU will be inserted following the last element. The first input of the POU is linked to the branch to the left of the selected position.

All POU inputs that could not be linked will receive the text "???". This text must be clicked and changed into the desired constant or variable.

If there is a branch to the right of an inserted POU, then the branch will be assigned to the first POU output. Ansonsten bleiben die Ausgänge unbelegt.

5.4.2.7 'Insert' 'Input'

Symbol: **Shortcut: <Ctrl>+<U>**

This command inserts an operator input. With many operators, the number of inputs may vary. (For example, ADD can have 2 or more inputs.)

In order to extend such an operator by an input, you need to select the input in front of which you wish to insert an additional input (Cursor Position 1); or you must select the operator itself (Cursor Position 3), if a lowest input is to be inserted (see 'Cursor positions in FBD').

The inserted input is allocated with the text "???". This text must be clicked and changed into the desired constant or variable. For this you can also use the Input Assistant.

5.4.2.8 'Insert' 'Output'

Symbol:

This command inserts an additional assignment into an existing assignment. This capability serves the placement of so-called assignment combs; i.e., the assignment of the value presently located at the line to several variables.

If you select the lined cross above an assignment (Cursor Position 5) (see 'Cursor positions in FBD') or the output directly in front of it (Cursor Position 4), then there will be another assignment inserted after the ones already there.

If the line cross directly in front of an assignment is selected (Cursor Position 4), then another assignment will be inserted in front of this one.

The inserted output is allocated with the text "???". This text must be clicked and changed into the desired variable. For this you can also use the Input Assistant.

5.4.2.9 'Extras' 'Negate

Symbol: **Shortcut: <Ctrl>+<N>**

With this command you can negate the inputs, outputs, jumps, or RETURN instructions. The symbol for the negation is a small circle at a connection.

If an input is selected (Cursor Position 2) (see 'Cursor positions in FBD'), then this input will be negated.

If an output is selected (Cursor Position 4), then this output will be negated.

If a jump or a return is marked, then the input of this jump or return will be negated.

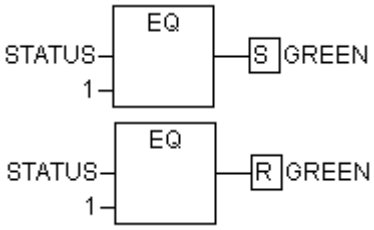
A negation can be canceled through renewed negation.

5.4.2.10 'Extras' 'Set/Reset'

Symbol:

With this command you can define outputs as Set or Reset Outputs. A grid with Set Output is displayed with [S], and a grid with Reset Output is displayed with [R].

X Set/Reset Outputs in FBD



An *Output Set* is set to TRUE, if the grid belonging to it returns TRUE. The output now maintains this value, even if the grid jumps back to FALSE.

An *Output Reset* is set to FALSE, if the grid belonging to it returns FALSE. The output maintains its value, even if the grid jumps back to FALSE.

With multiple executions of the command, the output will alternate between set, reset, and normal output.

5.4.2.11 Cutting, Copying, Pasting, and Deleting in FBD

The commands used to **'Cut'**, **'Copy'**, **'Paste'**, and **'Delete'** are found under the **'Edit'** menu item.

If a line cross is selected(Cursor Position 5) (see 'Cursor positions in FBD'), then the assignments, jumps, or RETURNS located below the crossed line will be cut, deleted, or copied.

If a POU is selected (Cursor Position 3), then the selected object itself, will be cut, deleted, or copied, along with all of the branches dependent on the inputs, with the exception of the first (highest position) branch.

Otherwise, the entire branch located in front of the cursor position will be cut, deleted, or copied.

After copying or cutting, the deleted or copied part is located on the clipboard and can now be pasted, as desired.

In order to do so, you must first select the pasting point. Valid pasting points include inputs and outputs.

If a POU has been loaded onto the clipboard (As a reminder: in this case all connected branches except the first are located together on the clipboard), the first input is connected with the branch before the pasting point.

Otherwise, the entire branch located in front of the pasting point will be replaced by the contents of the clipboard.

In each case, the last element pasted is connected to the branch located in front of the pasting point.

Note:
The following problem is solved by cutting and pasting: A new operator is inserted in the middle of a network. The branch located on the right of the operator is now connected with the first input, but should be connected with the second input. You can now select the first input and perform the command **'Edit' 'Cut'**. Following this, you can select the second input and perform the command **'Edit' 'Paste'**. This way, the branch is dependent on the second input.

5.4.2.12 The Function Block Diagram in the Online Mode

In the Function Block Diagram, breakpoints can only be set to networks. If a breakpoint has been set to a network, then the network numbers field will be displayed in blue. The processing then stops in front of the network where the breakpoint is located. In this case, the network numbers field will become red. Using stepping (single step), you can jump from network to network.

The current value is displayed for each variable. Exception: If the input to a function block is an expression, only the first variable in the expression is monitored.

Doubleclicking on a variable opens the dialog box for writing a variable. Here it is possible to change the present value of the variable. In the case of Boolean variables, no dialog box appears; these variables are toggled.

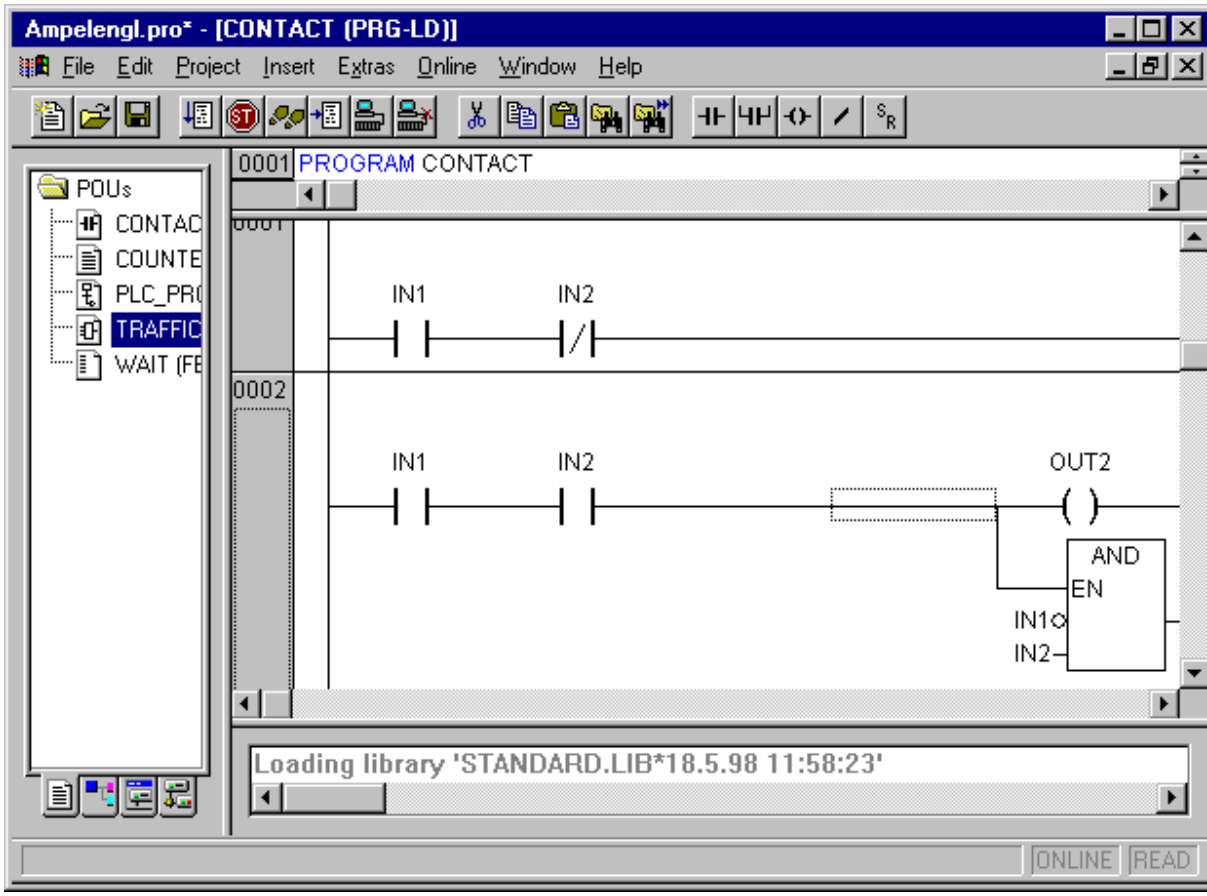
The new value will turn red and will remain unchanged. If the 'Online' 'Write values' command is given, then all variables are placed in the selected list and are once again displayed in black.

The flow control is started with the 'Online' 'Flow control' command Using the flow control, you can view the present values that are being carried in the networks over the connecting lines. If the connecting lines do not carry Boolean values, then the value will be displayed in a specially inserted field. If the lines carry Boolean values, then they will be shaded blue in the event that they carry TRUE. By this means, you can accompany the flow of information while the PLC is running.

If you place the mouse pointer briefly above a variable, then the type, the address and the comment about the variable will be displayed in a Tooltip.

5.4.3 The Ladder Editor

This is how a POU written in the LD appears in the **WAGO-I/O-*PRO* 32** editor:



All editors for POUs consist of a declaration part and a body. These are separated by a screen divider.

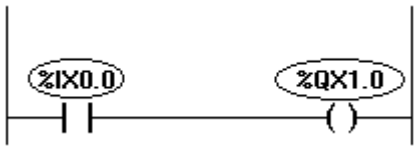
The LD editor is a graphic editor. The most important commands are found in the context menu (right mouse button or <Ctrl>+<F10>).

For information about the elements, see Ladder Diagram (LD).

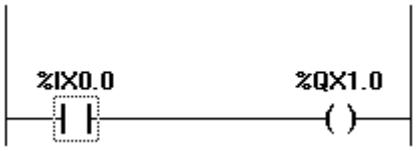
5.4.3.1 Cursor Positions in the LD Editors

The following locations can be cursor positions, in which the function block and program accessing can be handled as contacts. POUs with EN inputs and other POUs connected to them are treated the same way as in the Function Block Diagram. Information about editing this network part can be found in the chapteron the FBD Editor.

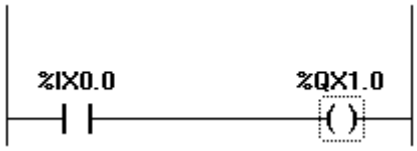
1. Every text field (possible cursor positions framed in black)



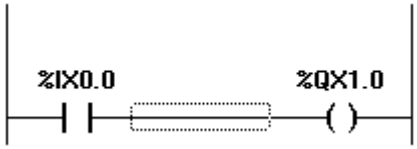
2. Every Contact or Function Block



3. Every Coil



4. The Connecting Line between the Contacts and the Coils.



The Ladder Diagram uses the following menu commands in a special way:

5.4.3.2 'Insert' 'Contact'in LD

Symbol: **Shortcut: <Ctrl>+<O>**

Use this command in the LD editor in order to insert a contact in front of the marked location in the network.

If the marked position is a coil or the connecting line between the contacts and the coils, then the new contact will be connected serially to the previous contact connection.

The contact is preset with the text "???". You can click on this text and change it to the desired variable or the desired constant. For this you can also use the Input Assistant.

5.4.3.3 'Insert' 'Parallel Contact'

Symbol: **Shortcut: <Ctrl>+<R>**

Use this command in the LD editor to insert a contact parallel to the marked position in the network.

If the marked position is a coil or the connection between the contacts and the coils, then the new contact will be connected in parallel to the entire previous contact connection.

The contact is preset with the text "???". You can click on this text and change it to the desired variable or the desired constant. For this you can also use the Input Assistant.

5.4.3.4 'Insert' 'Function Block in LD'

Shortcut: <Ctrl>+<B>

Use this command in order to insert an operator, a function block, a function or a program as a POU. For this, the connection between the contacts and the coils, or a coil, must be marked. The new POU at first has the designation AND. If you wish, you can change this designation to another one. For this you can also use the Input Assistant. Both standard and self-defined POUs are available.

The first input to the POU is placed on the input connection, the first output on the output connection; thus these variables must definitely be of type BOOL. All other in- and outputs of the POU are filled with the text "???". These prior entries can be changed into other constants, variables or addresses. For this you can also use the Input Assistant.

5.4.3.5 'Insert''Coil' in LD

Symbol: **Shortcut: <Ctrl>+<L>**

You can use this command in the LD editor to insert a coil in parallel to the previous coils.

If the marked position is a connection between the contacts and the coils, then the new coil will be inserted as the last. If the marked position is a coil, then the new coil will be inserted directly above it.

The coil is given the text "???" as a default setting. You can click on this text and change it to the desired variable. For this you can also use the Input Assistant.

5.4.3.6 POUs with EN Inputs

If you want to use your LD network as a PLC for calling up other POUs , then you must merge a POU with an EN input. Such a POU is connected in parallel to the coils. Beyond such a POU you can develop the network further, as in the Function Block Diagram. You can find the commands for insertion at an EN POU under the menu item **'Insert' 'Insert at Blocks'**

An operator, a function block, a program or a function with EN input performs the same way as the corresponding POU in the Function Block Diagram, except that its execution is controlled on the EN input. This input is annexed at

the connecting line between coils and contacts. If this connection carries the information "On", then the POU will be evaluated.

If a POU has been created once already with EN input, then this POU can be used to create a network. This means that data from usual operators, functions, and function blocks can flow in an EN POU and an EN POU can carry data to such usual POUs.

If, therefore, you want to program a network in the LD editor, as in FBD, you only need first to insert an EN operator in a new network. Subsequently, from this POU, you can continue to construct from your network, as in the FBD editor. A network thus formed will perform like the corresponding network in FBD.

5.4.3.7 'Insert' 'Box with EN in LD'

Use this command to insert a function block, an operator, a function or a program with EN input into a LD network.

The marked position must be the connection between the contacts and the coils (Cursor Position 4) or a coil (Cursor Position 3). The new POU is inserted in parallel to the coils and underneath them; it contains initially the designation "AND". If you wish, you can change this designation to another one. For this you can also use the Input Assistant.

5.4.3.8 'Insert' 'Function Block with EN'

With this command you can insert a function block with EN input into a LD network.

The marked position must be the connection between the contacts and the coils (Cursor Position 4) or a coil (Cursor Position 3). The new function block is inserted in parallel to the coils, below them. From the Input Assistantdialog box that appears, you can select whether to insert a user-defined, or a standard (default) function block.

5.4.3.9 'Insert' 'Function with EN'

With this command you can insert a function with EN input into an LD network.

The marked position must be the connection between the contacts and the coils (Cursor Position 4) or a coil (Cursor Position 3). The new function is inserted in parallel to the coils, below them. From the Input Assistantdialog box that appears, you can select whether to insert a user-defined, or a standard function block.

5.4.3.10 'Insert' 'Insert at blocks in LD

With this command you can insert additional elements into a POU that has already been inserted (also a POU with EN input). The commands below this

menu item can be executed at the same cursor positions as the corresponding commands in the Function Block Diagram.

With **Input** you can add a new input to the POU.

With **Output** you can add a new output to the POU.

With **POU**, you insert a new POU. The procedure is similar to that described under 'Insert' 'POU'.

With **Assign** you can insert an assignment to a variable. At first, this is shown by three question marks "???", which you edit and replace with the desired variable. Input assistance is available for this purpose.

5.4.3.11 'Insert' 'Jump' in LD

With this command you can insert a parallel jump in the selected LD editor, in parallel, at the end of the previous coils. If the incoming line delivers the value "On", then the jump will be executed to the indicated label.

The marked position must be the connection between the contacts and the coilsor a coil.

The jump is present with the text "???". You can click on this text and make a change in the desired label.

5.4.3.12 'Insert' 'Return' in LD

In the LD editor, you can use this command to insert a Return instruction in parallel at the end of the previous coils. If the incoming line delivers the value "On," then the processing of the POU in this network is broken off.

The marked position must be the connection between the contacts and the coilsor a coil.

5.4.3.13 'Extras' 'Paste after' in LD

Mit diesem Befehl fügen Sie im KOP-Editor den Inhalt der Zwischenablage als seriellen Kontakt nach der Markierungsstelle ein. Dieser Befehl ist nur möglich, wenn der Inhalt der Zwischenablage und die markierte Stelle Netzwerke aus Kontakten sind.

5.4.3.14 'Extras' 'Paste below'in LD

Shortcut: <Ctrl>+<U>

Use this command in the LD editor to insert the contents of the clipboard as parallel contact below the marked position. This command is only possible if the contents of the clipboard and the marked position are networks comprised of contacts.

5.4.3.15 'Extras' 'Paste above' in LD

Use this command in the LD editor to insert the contents of the clipboard as parallel contact above the marked position. This command is only possible if the contents of the clipboard and the marked position are networks comprised of contacts.

5.4.3.16 'Extras' 'Negate' in LD

Symbol: **Shortcut: <Strg>+<N>**

Use this command to negate a contact, a coil, a jump or return instruction, or an input or output of EN POUs at the present cursor position .

Between the parentheses of the coil or between the straight lines of the contact, a slash will appear ((/) or |/|). If there are jumps, returns, or inputs or outputs of EN POUs, a small circle will appear at the connection, just as in the FBD editor.

The coil now writes the negated value of the input connection in the respective Boolean variable. Right at this moment, a negated contact switches the status of the input to the output, if the respective Boolean variable carries the value FALSE.

If a jump or a return is marked, then the input of this jump or return will be negated.

A negation can be canceled through renewed negation.

5.4.3.17 'Extras' 'Set/Reset' in LD

If you execute this command on a coil, then you will receive a Set Coil. Such a coil never overwrites the value TRUE in the respective Boolean variable. This means that once you have set the value of this variable to TRUE, it will always remain at TRUE. A Set Coil is designated with an "S" in the coil symbol.

If you execute this command once again, then you will be given a Reset coil. Such a coil never overwrites the value FALSE in the respective Boolean variable. This means that once you have set the value of this variable to FALSE, it will always remain at FALSE. A Reset Coil is designated with an "R" in the coil symbol.

If you execute this command repeatedly, the coil will alternate between set, reset and normal coil.

5.4.3.18 The Ladder Diagram in the Online Mode

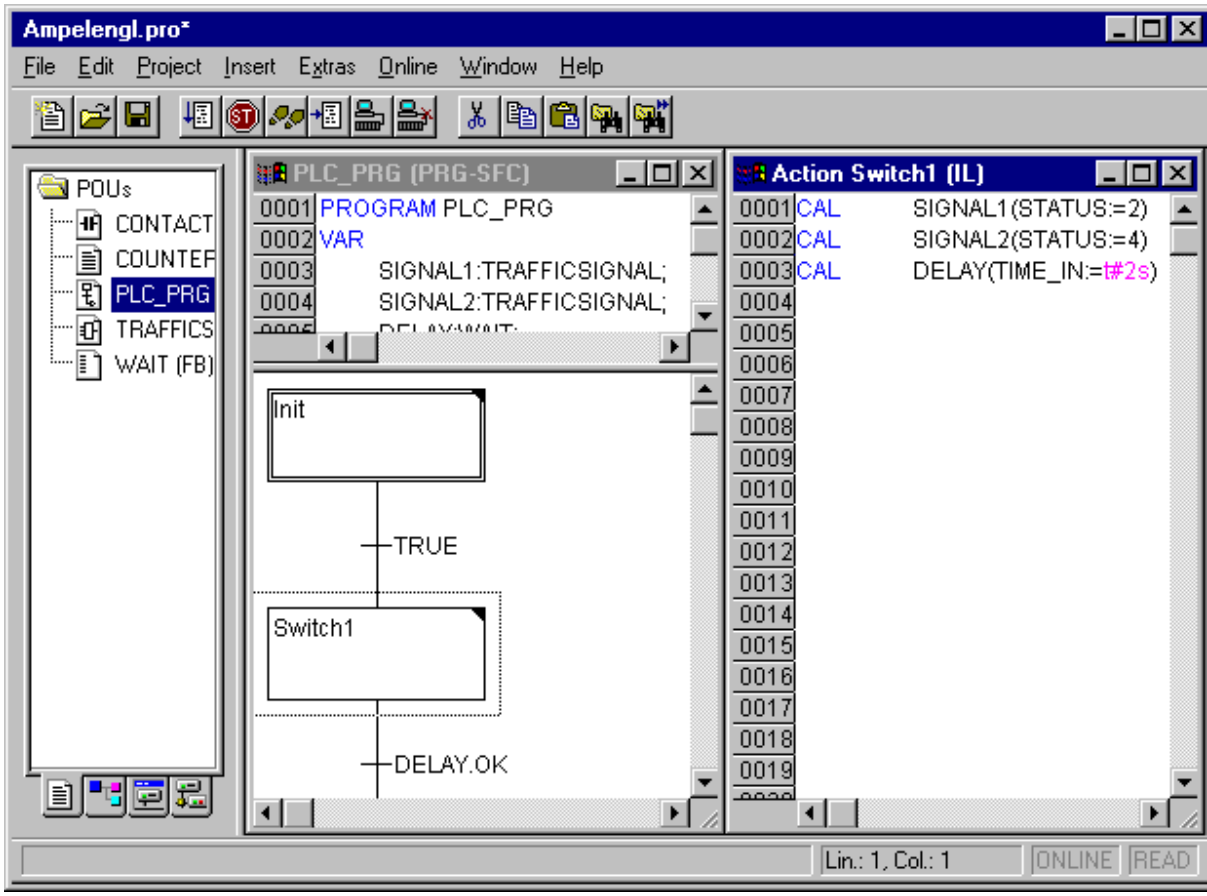
In Online mode, the contacts and coils in the Ladder Diagram that are in the "On" state are colored blue. Likewise, all lines over which the "On" is carried are also colored blue. At the inputs and outputs of function blocks, the values of the corresponding variables are indicated.

Breakpoints can only be set on networks; by using stepping, you can jump from network to network.

If you place the mouse pointer briefly above a variable, then the type, the address and the comment about the variable will be displayed in a Tooltip.

5.4.4 The Sequential Function Chart Editor

This is how a POU written in the SFC appears in the **WAGO-I/O-*PRO* 32** editor:



All editors for POUs consist of a declaration part and a body. These are separated by a screen divider.

The Sequential Function Chart editor is a graphic editor. The most important commands are found in the context menu (right mouse button or <Ctrl><F10>). Tooltips show in Offline as well as in Online mode and in the zoomed state the full names or expressions of steps, transitions, jumps, jump labels, qualifiers or associated actions.

For information about the Sequential Function Chart see 'Sequential Function Chart'.

The editor for the Sequential Function Chart must agree with the particulars of the SFC. In reference to these, the following menu items will be of service.

5.4.4.1 Marking Blocks in the SFC

A marked block is a bunch of SFC elements that are enclosed in a dotted rectangle.

You can select an element (a step, a transition, or a jump) by pointing the mouse on this element and pressing the left mouse button, or you can use the arrow keys. In order to mark a group of several elements, press <Shift> for a block already marked, and select the element in the lower left or right corner of the group. The resulting selection is the smallest cohesive group of elements that includes both of these elements.

Observe that all commands can only be executed, if they do not contradict the conventions of the language.

5.4.4.2 'Insert' 'Step Transition (before)'

Symbol: **Shortcut: <Ctrl>+<T>**

This command inserts a step in the SFC editor followed by a transition in front of the marked block.

5.4.4.3 'Insert' 'Step Transition (after)'

Symbol: **Shortcut: <Ctrl>+<E>**

This command inserts a step in the SFC editor followed by a transition after the first transition in the marked block.

5.4.4.4 'Insert' 'Alternative Branch (right)'

Symbol: **Shortcut: <Ctrl>+<A>**

This command inserts an alternative branch in the SFC editor as a right branch of the marked block. For this the marked block must both begin and end with a transition. The new branch is then made up of one transition.

5.4.4.5 'Insert' 'Alternative Branch (left)'

Symbol:

This command inserts an alternative branch in the SFC editor as the left branch of the marked block. For this the marked block must both begin and end with a transition. The new branch is then made up of one transition.

5.4.4.6 'Insert' "Parallel Branch (right)"

Symbol: **Shortcut: <Ctrl>+<L>**

This command inserts a parallel branch in the SFC editor as the right branch of the marked block. For this the marked block must both begin and end with a step. The new branch is then made up of one step. To allow jumps to the parallel branches that have been created, these must be provided with a jump label.

5.4.4.7 'Insert' 'Parallel Branch (left)'

Symbol:

'This command inserts a parallel branch in the SFC editor as the left branch of the marked block. For this the marked block must both begin and end with a step. The new branch is then made up of one step. To allow jumps to the parallel branches that have been created, these must be provided with a jump label (see 'Extras' 'Add label to parallel branch').

5.4.4.8 'Insert' 'Jump'

'This command inserts a jump in the SFC editor at the end of the branch, to which the marked block belongs. For this the branch must be an alternative branch.

The inserted text string 'Step' in the inserted jump can then be selected and replaced by the step name or the jump label of a parallel branch to be jumped to.

5.4.4.9 'Insert' 'Transition-Jump'

Symbol:

This command inserts a transition in the SFC editor, followed by a jump at the end of the selected branch. For this the branch must be a parallel branch.

The inserted text string 'Step' in the inserted jump can then be selected and replaced by the step name or the jump label of a parallel branch to be jumped to.

5.4.4.10 'Insert' 'Add Entry-Action'

With this command you can add an entry action to a step. An entry-action is only executed once, right after the step has become active. The entry-action can be implemented in a language of your choice.

A step with an entry-action is designated by an "E" in the bottom left corner.

5.4.4.11 'Insert' 'Add Exit-Action'

With this command you can add an exit-action to a step. An exit-action is only executed once, before the step is deactivated. The exit-action can be implemented in a language of your choice.

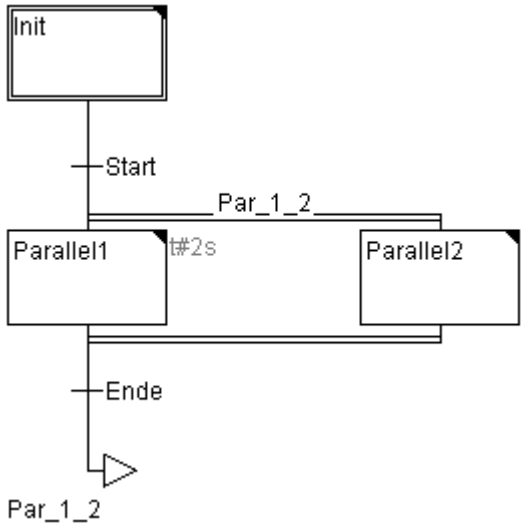
A step with an exit-action is designated by an "X" in the lower right corner.

5.4.4.12 'Extras' 'Paste Parallel Branch (right)'

This command pastes the contents of the clipboard as a right parallel branch of the marked block. For this the marked block must both begin and end with a step. The contents of the clipboard must, likewise, be an SFC block that both begins and ends with a step.

5.4.4.13 'Extras' 'Add label to parallel branch'

In order to provide a newly inserted parallel branch with a jump label, the transition occurring before the parallel branching must be marked and the command 'Add label to parallel branch' must be executed. At that point, the parallel branch will be given a standard name consisting of "Parallel" and an appended serial number, which can be edited according to the rules for identifier names. In the following example, "Parallel" was replaced by "Par_1_2" and the jump to the transition "End" was steered to this jump label.



5.4.4.14 Delete a label

A jump label can be deleted by deleting the label name.

5.4.4.15 'Extras' 'Paste after'

This command pastes the SFC block on the clipboard after the first step or the first transition of the marked block. (Normal copying pastes it in front of the marked block.) This will now be executed, if the resulting SFC structure is correct, according to the language norms.

5.4.4.16 'Extras' 'Zoom Action/Transition'

Shortcut: <Alt>+<Enter>

The action of the first step of the marked block or the transition body of the first transition of the market block is loaded into the editor in the respective

language, in which it has been written. If the action or the transition body is empty, then the language must be selected, in which it has been written.

5.4.4.17 'Extras' "Clear Action/Transition"

With this command you can delete the actions of the first step of the marked block or of the transitions body of the first transition.

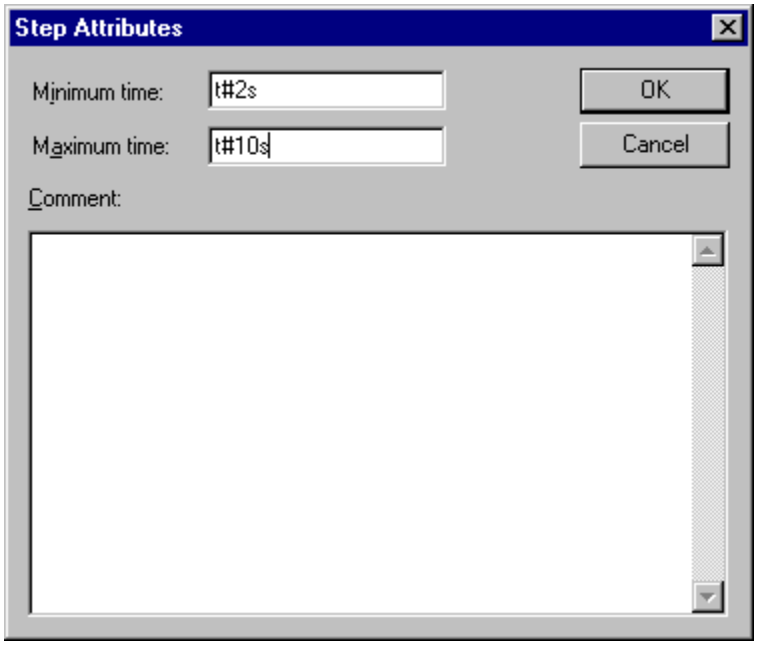
If, during a step, you implement either only the action, the entry-action, or the exit-action, then the same will be deleted by the command. Otherwise a dialog box appears, and you can select which action or actions are to be deleted.

If the cursor is located in the action of an IEC step, then only this association will be deleted. If an IEC step with an associated action is selected, then this association will be deleted. During an IEC step with several actions, a selection dialog box will appear.

5.4.4.18 'Extras' 'Step Attributes'

With this command you can open a dialog box in which you can edit the attributes for the marked step.

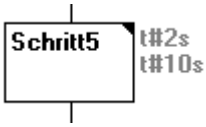
X Dialog Box for Editing Step Attributes



You can take advantage of three different entries in the step attribute dialog box. Under **Minimum Time**, you enter the minimum length of time that the processing of this step should take. Under the **Maximum Time**, you enter the maximum length of time that the processing of this step should take. Note that the entries are of the **TIME** type, so you use a TIME constant (i.e. T#3s) or a variable of the TIME type.

Under **Comment** you can insert a comment to the step. In the 'Sequential function chart options' dialog which you open under 'Extras' 'Options', you can then enter whether comments or the time setting is displayed for the steps in the SFC editor. On the right, next to the step, either the comment or the time setting will appear.

If the maximum time is exceeded, SFC flags are set which the user can query.

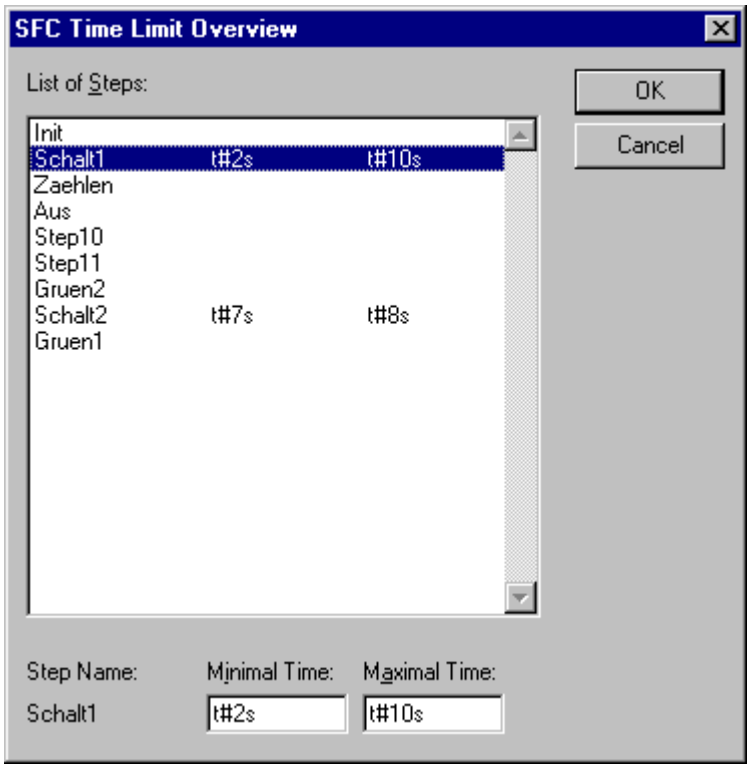


The example shows a step whose execution should last at least two, and at the most, ten seconds. In Online mode, there is, in addition to these two times, a display of how long the step has already been active.

5.4.4.19 'Extras' 'Time Overview'

With this command you can open a window in which you can edit the time settings of your SFC steps:

X Time Boundaries Overview for a SFC POU



In the time boundaries overview, all steps of your SFC POU are displayed. If you have entered a time boundary for a step, then the time boundary is displayed to the right of the step (first, the lower limit, then the upper limit). You can also edit the time boundaries. To do so, click on the desired step in the overview. The name **of the step** is then shown below in the window. Go to the **Minimum Time** or **Maximum Time** field, and enter the desired time

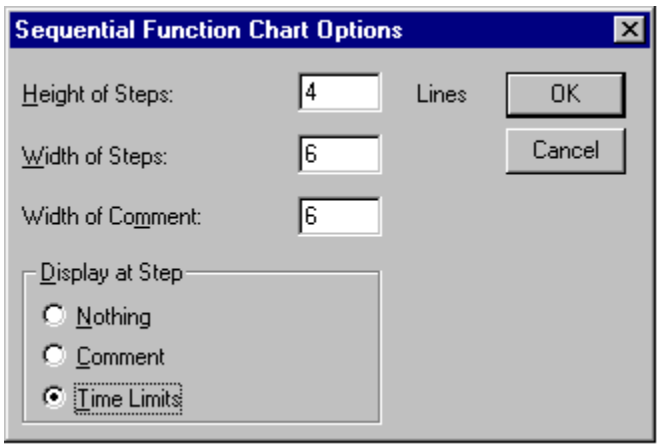
boundary there. If you close the window with **OK**, then all of the changes will be stored.

In the example, steps 2 and 6 have a time boundary. Shift1 lasts at least two, and at most, ten seconds. Shift2 lasts at least seven, and at most, eight seconds.

5.4.4.20 'Extras' 'Options'

With this command you open a dialog box in which you can set different options for your SFC POU.

X Dialog Box for Sequential Function Chart Options



In the SFC Options dialog box you can undertake five entries. Under **Step Height**, you can enter how many lines high an SFC step can be in your SFC editor. 4 is the standard setting here. Under **Step Width**, you can enter how many columns wide a step should be. 6 is the standard setting here. You can also preset the **Display at Step**. With this, you have three possibilities: You can either have **Nothing** displayed, or the **Comment**, or the **Time Limits**. The last two are shown the way you entered them in 'Extras' 'Step Attributes'.

5.4.4.21 'Extras' 'Associate Action'

With this command actions and Boolean variables can be associated with IEC steps.

To the right of, and next to the IEC step, an additional divided box is attached, for the association of an action. It is preset in the left field with the qualifier "N" and the name "Action." Both presets can be changed. For this you can use the Input Assistant.

New actions for IEC steps are created in the Object Organizer for an SFC POU with the **'Project' 'Add Action'** command.

5.4.4.22 'Extras' 'Use IEC-Steps'

Symbol:

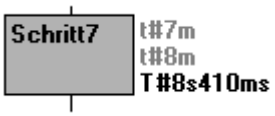
If this command is activated (denoted by a check in front of the menu item and a printed symbol in the Tool bar), then IEC steps will be inserted instead of the simplified steps upon insertion of step transitions and parallel branches.

If this option is switched on, the Init step is set as an IEC step when you create a new SFC POU.

This settings are saved in the file "WAGO-I/O-PRO 32.ini" and are restored when **WAGO-I/O-*PRO* 32** gets started again.

5.4.4.23 Sequential Function Chart in Online Mode

With the Sequential Function Chart editor in Online mode, the currently active steps will be displayed in blue. If you have set it under 'Extras' 'Options', then the time management is depicted next to the steps. Under the lower and upper bounds that you have set, a third time indicator will appear from which you can read how long the step has already been active.



In the picture above the step depicted has already been active 8 seconds and 410 milliseconds. The step must, however, be active for at least 7 minutes before the step will be left.

With **'Online' 'Toggle Breakpoint'** a breakpoint can be set on a step, or in an action at the locations allowed by the language in use. Processing then stops prior to execution of this step or before the location of the action in the program. Steps or program locations where a breakpoint is set are marked in light blue.

If several steps are active in a parallel branch, then the active step whose action will be processed next is displayed in red.

If IEC steps have been used, then all active actions in Online mode will be displayed in blue.

With the command **'Online' 'Step over'** it is stepped always to the next step which action is executed. If the current location is:

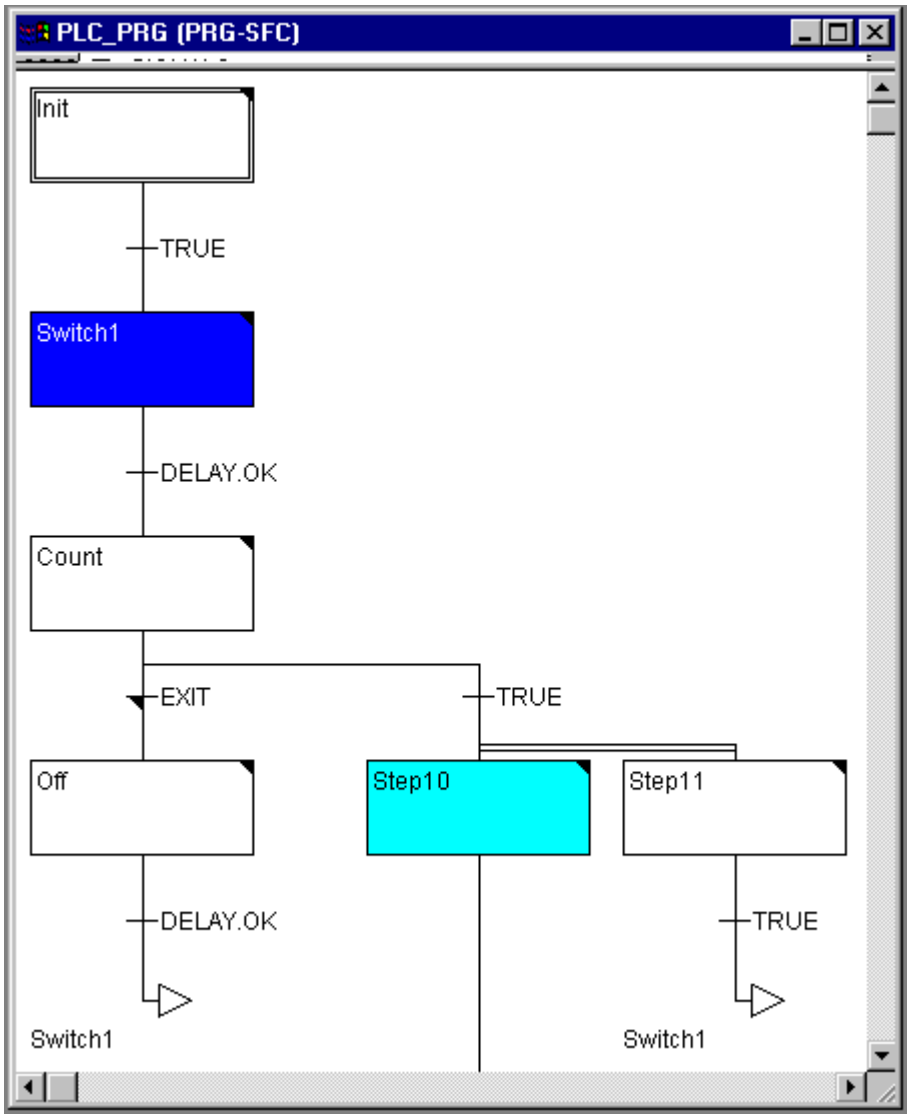
- a step in the linear processing of a POU or a step in the rightmost parallel branch of a POU, execution returns from the SFC POU to the caller. If the POU is the main program, the next cycle begins.
- a step in a parallel branch other than the rightmost, execution jumps to the active step in the next parallel branch.
- the last breakpoint location within a **WAGO-I/O-*PRO* 32** action, execution jumps to the caller of the SFC.
- the last breakpoint location within an IEC action, execution jumps to the caller of the SFC.

- the last breakpoint position within an input action or output action, execution jumps to the next active step.

With **'Online' 'Step in'** even actions can be stepped into. If an input, output or IEC action is to be jumped into, a breakpoint must be set there. Within the actions, all the debugging functionality of the corresponding editor is available to the user.

If you rest the mouse cursor for a short time on a variable in the declaration editor, the type, the address and the comment of the variable will be displayed in a **tooltip**

X Sequential Function Chart with an Active Step (Shift1) and a Breakpoint (Step10)



Note:
Please refer to following processing order of elements in a sequence.

1. First, all Action Control Block flags in the IEC actions that are used in this sequence are reset (not, however, the flags of IEC actions that are called within actions).

2. All steps are tested in the order which they assume in the sequence (top to bottom and left to right) to determine whether the requirement for execution of the output action is provided, and this is executed if that is the case.

3. All steps are tested in the order which they assume in the sequence to determine whether the requirement for the input action is provided, and this is executed if that is the case.

4. For all steps , the following is done in the order which they assume in the sequence:
- If applicable, the elapsed time is copied into the corresponding step variable.
- If applicable, any timeout is tested and the SFC error flags are serviced as required.
- For non-IEC steps, the corresponding action is now executed.

5. IEC actions that are used in the sequence are executed in alphabetical order. This is done in two passes through the list of actions. In the first pass, all the IEC actions that are deactivated in the current cycle are executed. In the second pass, all the IEC actions that are active in the current cycle are executed.

6. Transitions are evaluated: If the step in the current cycle was active and the following transition returns TRUE (and if applicable the minimum active time has already elapsed), then the following step is activated.

The following must be noted concerning implementation of actions:

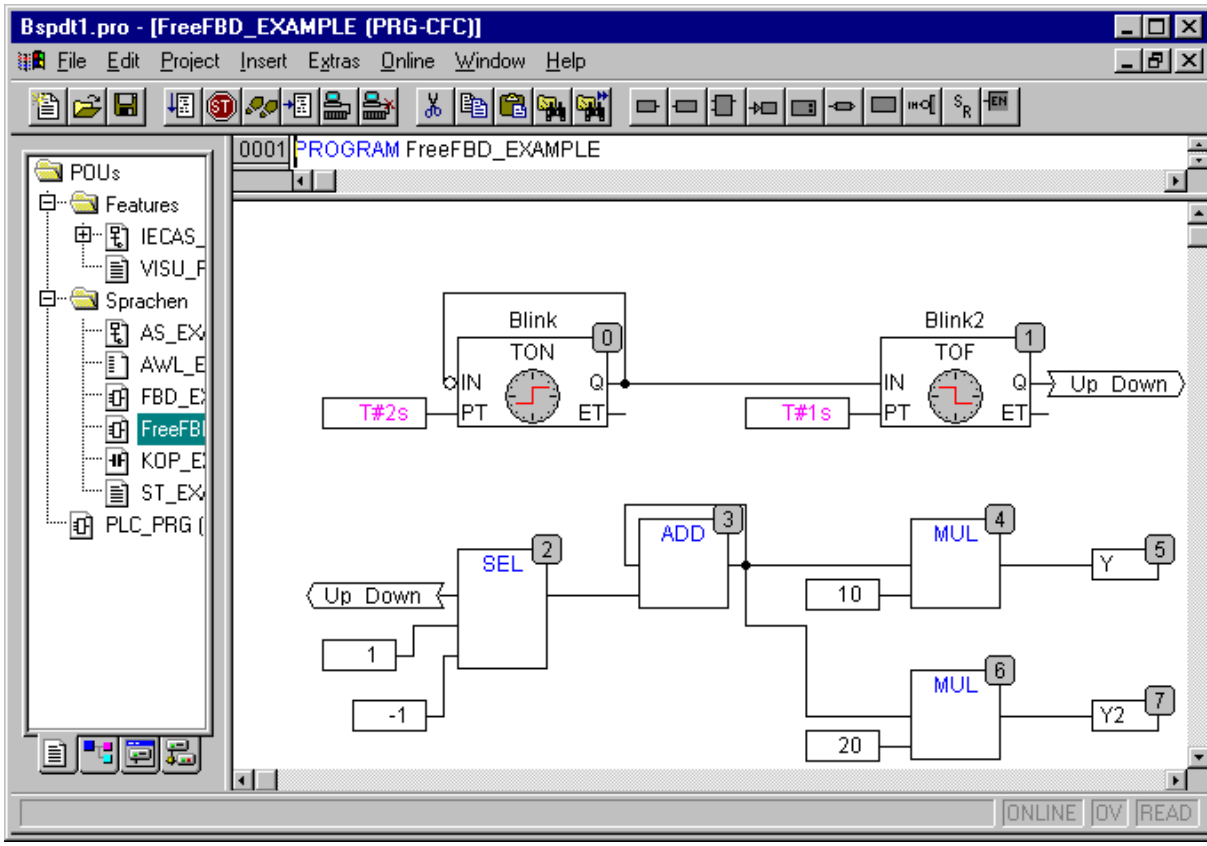
It can come about that an action is carried out several times in one cycle because it is associated with multiple sequences. (For example, an SFC could have two IEC actions A and B, which are both implemented in SFC, and which both call IEC action C; then in IEC actions A and B can both be active in the same cycle and furthermore in both actions IEC action C can be active; then C would be called twice).

If the same IEC action is used simultaneously in different levels of an SFC, this could lead to undesired effects due to the processing sequence described above. For this reason, an error message is issued in this case. It can possibly arise during processing of projects created with older versions of **WAGO-I/O-*PRO* 32**.

Note:
In monitoring expressions (e.g. A AND B) in transitions, only the "Total value" of the transition is displayed.

5.4.5 The Continuous Function Chart Editor (CFC)

It looks like a block which has been produced using the continuous function chart editor (CFC):



No snap grid is used for the continuous function chart editor so the elements can be placed anywhere. Elements of the sequential processing list include boxes, input, output, jump, label, return and comments. The inputs and outputs of these elements can be connected by dragging a connection with the mouse. The connecting line will be drawn automatically. The shortest possible connection line is drawn taking into account existing connections. The connecting lines are automatically adjusted when the elements are moved. If the case arises where a connecting line cannot be drawn simply because of lack of space, a red line will be shown between the input and the associated output instead. This line will be converted into a connecting line just as soon as space is available.

One advantage of the continuous function chart as opposed to the usual function block diagram editor FBD is the fact that feedback paths can be inserted directly.

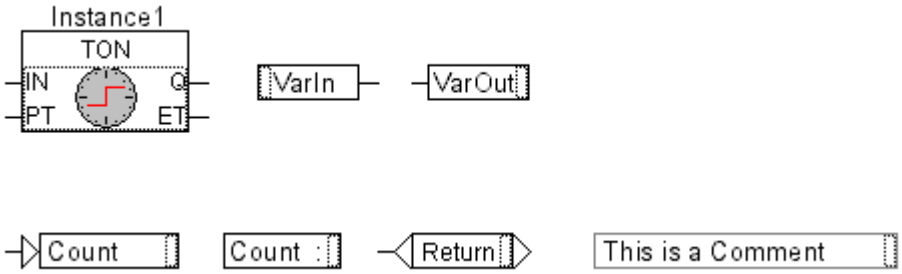
The most important commands can be found in the context menu

5.4.5.1 Cursor positions in the CFC

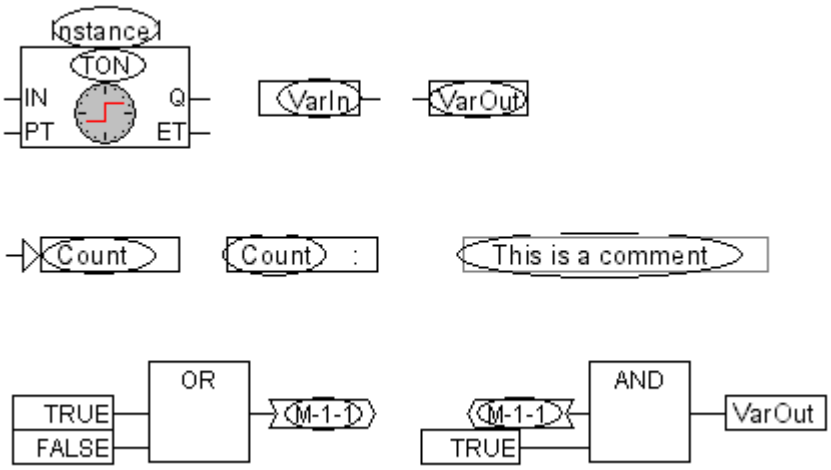
Each text is a possible cursor position. The selected text is shaded in blue and can be modified.

In all other cases the current cursor position is shown by a rectangle made up of points. The following is a list of all possible cursor positions with examples:

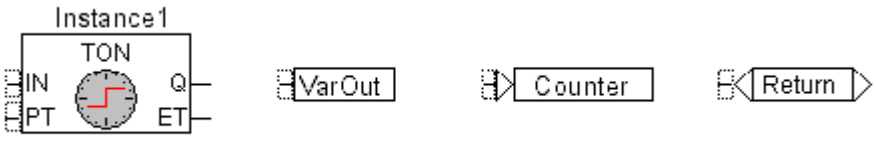
1. Trunks of the elements box, input, output, jump, label, return and comments.



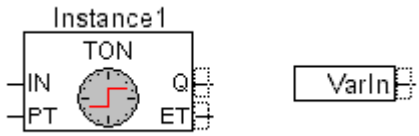
2. Text fields for the elements box, input, output, jump, label, return and comments as well as text fields for connection marker



3. Inputs for the elements box, input, output, jump and return



4. Outputs for the elements box and input:



5.4.5.2 'Insert' 'Box' in the CFC

Symbol: **Shortcut: <Ctrl>+<B>**

This command can be used to paste in operators, functions, function blocks and programs First of all, it is always inserted an "AND" operator. This can be converted by Selection and Overwrite of the text into every other operator, into every function, into every function block and every program. The input assistance serves to select the desired block from the list of supported blocks. If the new block has another minimum number of inputs, these will be attached. If the new block has a smaller highest number of inputs, the last inputs will be deleted.

5.4.5.3 ‚Insert' ‚Input' in CFC

Symbol: **Shortcut: <Ctrl> + <E>**

This command is used to insert an input. The text offered "???" can be selected and replaced by a variable or constant. The input assistance can also be used here.

5.4.5.4 'Insert' 'Output'in CFC

Symbol: **Shortcut: <Ctrl>+<A>**

This command is used to insert an output. The text offered "???" can be selected and replaced by a variable. The input assistance can also be used here. The value which is associated with the input of the output is allocated to this variable.

5.4.5.5 'Insert' 'Jump'in CFC

Symbol: **Shortcut: <Ctrl>+<J>**

This command is used to insert a jump. The text offered "???" can be selected and replaced by the jump label to which the program should jump.

The jump label is inserted using the command 'Insert 'Label'

5.4.5.6 'Insert' 'Label' in CFC

Symbol: **Shortcut: <Ctrl>+<L>**

This command is used to insert a label. The text offered "???" can be selected and replaced by the jump label. In Online mode a RETURN label for marking the end of POU is automatically inserted.

The jump is inserted using the command 'Insert 'Jump'

5.4.5.7 'Insert' 'Return' in CFC

Symbol: **Shortcut: <Ctrl> + <R>**

This command is used to insert a RETURN command. Note that in Online mode a jump label with the name RETURN is automatically inserted in the first column and after the last element in the editor; in stepping, it is automatically jumped to before execution leaves the POU.

5.4.5.8 'Insert' 'Comment' in CFC

Symbol: **Shortcut: <Ctrl> + <K>**

This command is used to insert a comment.

You obtain a new line within the comment with **<Ctrl> + <Enter>**.

5.4.5.9 'Insert' 'Input of box' in CFC

Shortcut: <Ctrl> + <U>

This command is used to insert an input at a box. The number of inputs is variable for many operators (e.g. ADD can have two or more inputs).

To increase the number of inputs for such an operator by one, the box itself must be selected

5.4.5.10 Insert' 'In-Pin' in CFC, 'Insert' 'Out-Pin'

Symbol:

These commands are available as soon as a macro is opened for editing. They are used for inserting in- or out-pins as in- and outputs of the macro. They differ from the normal in- and outputs of POUs by the way they are displayed and in that they have no position index.

5.4.5.11 'Extras' 'Negate' in CFC

Symbol: **Shortcut: <Ctrl> + <N>**

This command is used to negate inputs, outputs, jumps or RETURN commands. The symbol for the negation is a small cross on the connection.

The input of the element block, output, jump or return is negated when it is selected.

The output of the element block or input is negated when it is selected (Cursor position 4).

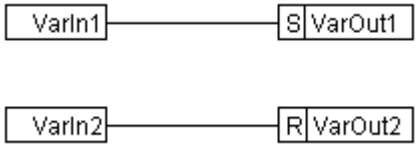
A negation can be deleted by negating again.

5.4.5.12 'Extras' 'Set/Reset' in CFC

Symbol: **Shortcut: <Ctrl> + <T>**

This command can only be used for selected inputs of the element output .

The symbol for Set is S and for Reset is R.



VarOut1 is set to TRUE, if VarIn1 delivers TRUE. VarOut1 retains this value, even when VarIn1 springs back to FALSE.

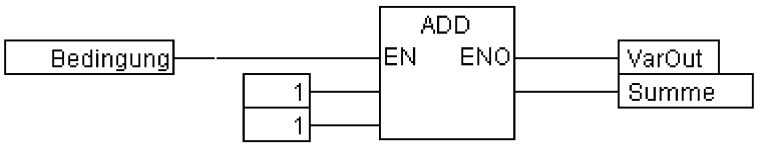
VarOut2 is set to FALSE, if VarIn2 delivers TRUE. VarOut2 retains this value, even when VarIn2 springs back to FALSE.

Multiple activation of this command causes the output to change between Set, Reset and the normal condition.

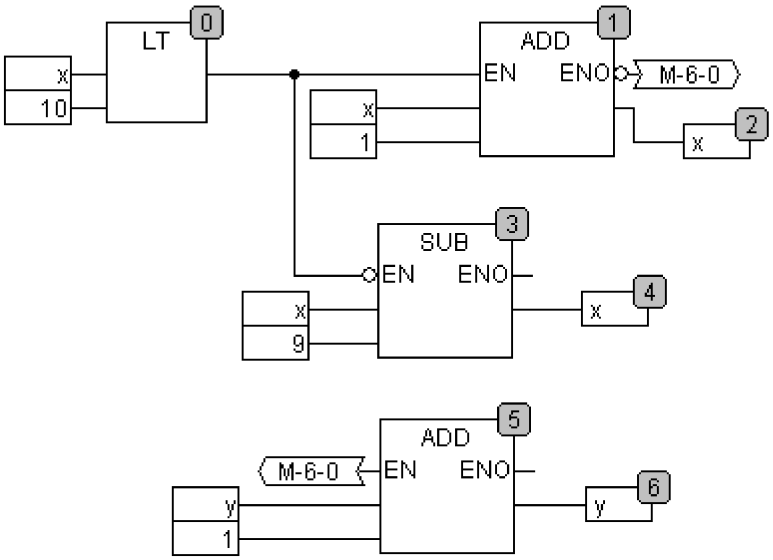
5.4.5.13 'Extras' 'EN/ENO' in CFC

Symbol: **Shortcut: <Ctrl> + <0>**

This command is used to give a selected block (Cursor position 3) an additional Boolean enable input EN (Enable In) and a Boolean output ENO (Enable Out).



ADD is only executed in this example when the Boolean variable "Bedingung" (condition) is TRUE. VarOut is also set to TRUE after ADD has been executed. ADD will not be executed when the variable "Bedingung" (condition) is FALSE and VarOut retains its value FALSE. The example below shows how the value ENO can be used for further blocks:



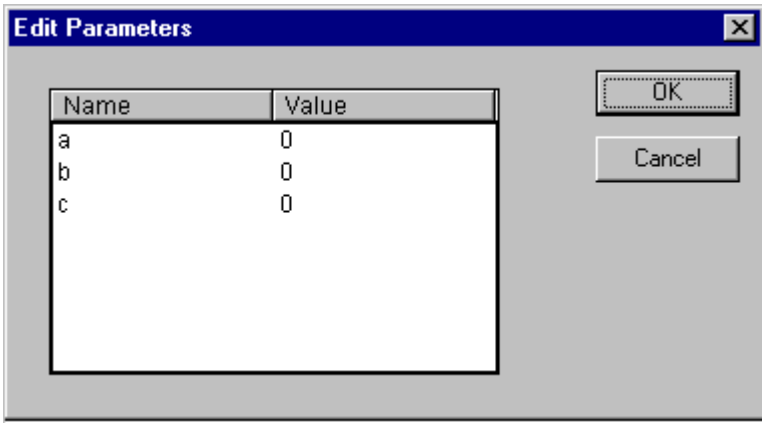
x should initialised to 1 and y initialised to 0. The numbers in the right corner of the block indicate the order in which the commands are executed.

x will be increased by one until it reaches the value 10. This causes the output of the block LT(0) to deliver the value FALSE and SUB(3) and ADD(5) will be executed. x is set back to the value 1 and y is increased by 1. LT(0) is executed again as long as x is smaller than 10. y thus count the number of times x passes though the value range 1 to 10.

5.4.5.14 ‚Extras' ‚Properties...' in CFC

Constant input parameters (VAR_INPUT CONSTANT) from functions and function blocks are not shown directly in the continuous function chart editor. These can be shown and their value can be changed when one selects the trunk of the block in question and then selects the command ‚Extras' ‚Properties' or simply double clicks on the trunk. The "Edit parameters" dialog opens:

X Properties dialog



The values of the constant input parameter (VAR_INPUT CONSTANT) can be changed. Here it is necessary to mark the parameter value in the column

Value. Another mouse click or pressing on the space bar allows this to be edited. Confirmation of the change to the value is made by pressing the <Enter> key or pressing <Escape> rejects the changes. The button **OK** stores all of the changes which were made.

5.4.5.15 Selecting elementsin CFC

One clicks on the trunk of the element to select it.

To mark more elements one presses the <Shift> key and clicks in the elements required, one after the other, or one drags the mouse with the left hand mousekey depressed over the elements to be marked.

The command **'Extras' 'Select all'** marks all elements at once.

5.4.5.16 Moving elementsin CFC

One or more selected elements can be moved with the arrow keys as one is pressing on the <Shift> key. Another possibility is to move elements using a depressed left mousekey. These elements are placed by releasing the left mousekey in as far as they do not cover other elements or exceed the foreseen size of the editor. The marked element jumps back to its initial position in such cases and a warning tone sounds.

5.4.5.17 Copying elementsin CFC

One or more selected elements can be copied with the command **'Edit' 'Copy'** and inserted with the command **'Edit' 'Paste'**.

5.4.5.18 Creating connections

An input of an element can be precisely connected to the output of another element. An output of an element can be connected to the inputs of a number of other elements.

There are a number of possibilities to connect the input of an element E2 with the output of an element E1.

Place the mouse on the output of element E1, click with the left mousekey, hold the left mousekey down and drag the mouse cursor onto the input of element E2 and let the left mousekey go. A connection is made from the output of element E1 to the mouse cursor during this dragging operation with the mouse.

Place the mouse on the input of element E2, click with the left mousekey, hold the left mousekey down and drag the mouse cursor onto the output of element E1 and let the left mousekey go.

Move one of the elements E1 or E2 and place it in such a way by letting go of the left mousekey that the output of element E2 and the input of element E1 touch.

Where element E2 is a block with a free input, a connection can also be made by dragging the mouse from an output from E1 to the trunk of E2. A connection with the free input at the highest position on E2 will be created when the mousekey is released. In the case where block E2 does not have a free input but is an operator which can have an input added to it, a new input will be automatically generated.

The output and input of a block can be connected together (feedback path) by using this method. To establish a connection between two pins, click with the left mouse button on one pin, hold the button down and thus drag the connection to the desired pin, where you then release the button. If during the dragging of the connection extends outside working area of the editor, scrolling occurs automatically. For simple data types, type testing is carried out during the connection. If the types of the two pins are not compatible, the cursor changes to "Forbidden". For complex data types, no testing takes place.

5.4.5.19 Deleting connections

There are a number of possibilities for removing the connection between the output of an element E1 and the input of an element E2:

Select the output of element E1 and press the <Delete> key or execute the command **'Edit' 'Delete'**. Several connections will be removed at the same if the output of E1 is connected to more than one of inputs.

Select the input of element E2 and press the <Delete> key or execute the command **'Edit' 'Delete'**.

Select the input of E2 with the mouse, hold the left mousekey depressed and drag the connection from the input to E2 away. The connection is removed when the left mousekey is released in a free area of the screen.

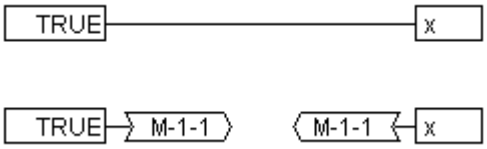
5.4.5.20 Changing connections

A connection between the output of an element E1 and the input of an element E2 can easily be changed into a connection between the output of element E1 and the input of element E3. The mouse is clicked on the input of E2, the left mousekey is kept depressed, the mouse cursor is moved to the input of E3 and then released.

5.4.5.21 'Extras' 'Connection marker'

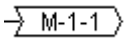
Connections can also be represented by a connector (connection marker) instead of a connecting line. Here the output and the associated input have a connector added to them which is given a unique name.

Where a connection already exists between the two elements which should now be represented by connectors, the output of the connecting line is marked and the menu point ‚Extras' ‚Connection marker' is selected. The following diagram shows a connection before and after the selection of this menu point.

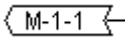


A unique name is given as standard by the program which begins with M, but which can be changed The connector name is stored as an output parameter, but can be edited both at the input and at the output.

It is important to know that the connector name is associated with a property of the output of a connection and is stored with it.

1. Edit the connector at the output: 

If the text in the connector is replaced, the new connector name is adopted by all associated connectors at the inputs. One cannot, however, select a name which already belongs to **another** connection marker since the uniqueness of the connector name would be violated.

2. Edit the connector at the input: 

If the text in a connector is replaced, it will also be replaced in the corresponding connection marker on the other POU. Connections in connector representations can be converted to normal connections in that one marks the output of the connections (Cursor position 4) and again selects the menu point **'Extras' 'Connection marker'**.

5.4.5.22 Insert inputs/outputs "on the fly"

If exactly one input or output pin of an element is selected, then the corresponding input- or output- element can be directly inserted and its editor field filled with a string by entering the string at the keyboard.

5.4.5.23 Order of execution

The elements block, output, jump, return and label each possess a number indicating the order in which they are executed. In this sequential order the individual elements are evaluated at run time.

When pasting in an element the number is automatically given according to the topological sequence (from left to right and from above to below). The new element receives the number of its topological successor if the sequence has already been changed and all higher numbers are increased by one.

The number of an element remains constant when it is moved.

The sequence influences the result and must be changed in certain cases.

If the sequence is displayed, the corresponding sequential execution number is shown in the upper right hand corner of the element.

5.4.5.24 'Extras' 'Order' 'Display'

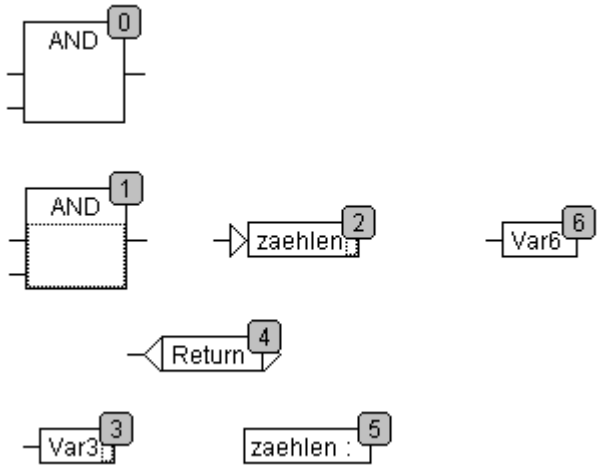
This command switches the display of the order of execution on and off. The default setting is to show it (recognised by a tick (✓) in front of the menu point).

The relevant order of execution number appears in the upper right hand corner for the elements block, output, jump, return and label.

5.4.5.25 'Extras' 'Order' 'Order topologically'

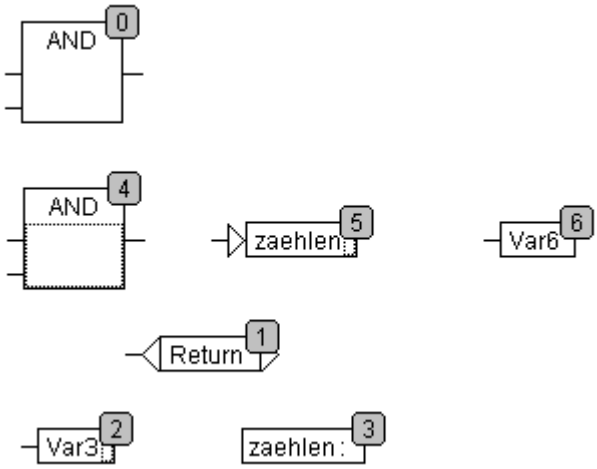
Elements are ordered in a topological sequence when the execution takes place from left to right and from above to below, that is the number increases from left to right and from above to below for topologically arranged elements. The connections are not relevant, only the location of the elements is important.

All **selected** elements are topologically arranged when the command **'Extras' 'Order' 'Order topologically'** is executed. All elements in the selection are taken out of the sequential processing list by this process. The elements are then entered into the remaining sequential processing list individually from bottom right through to upper left. Each marked element is entered into the sequential processing list before its topological successor, i.e. it is inserted before the element that in a topological sequencing would be executed after it, when all elements in the editor were sequenced according to a topological sequencing system. This will be clarified by an example.



The elements with numbers 1, 2 and 3 are selected. If the command **'Order topologically'** is selected the elements are first taken out of the sequential processing list. Var3, the jump and the AND-operator are then inserted again one after the other. Var3 is placed before the label and receives the number 2. The jump is then ordered and receives the number 4 at first but this then

becomes 5 after the AND is inserted. The new order of execution which arises is:



When a newly generated block is introduced it will be placed by default in front of its topological successor in the sequential processing list.

5.4.5.26 'Extras' 'Order' 'One forwards'

With this command all selected elements with the exception of the element which is at the beginning of the sequential processing list are moved one place forwards in the sequential processing list.

5.4.5.27 'Extras' 'Order' 'One backwards'

With this command all selected elements with the exception of the element which is at the end of the sequential processing list are moved one place backwards in the sequential processing list.

5.4.5.28 'Extras' 'Order' 'To the beginning'

With this command all selected elements will be moved to the front of the sequential processing list whereby the order within the group of selected elements is maintained. The order within the group of unselected elements also remains the same.

5.4.5.29 'Extras' 'Order' 'To the end'

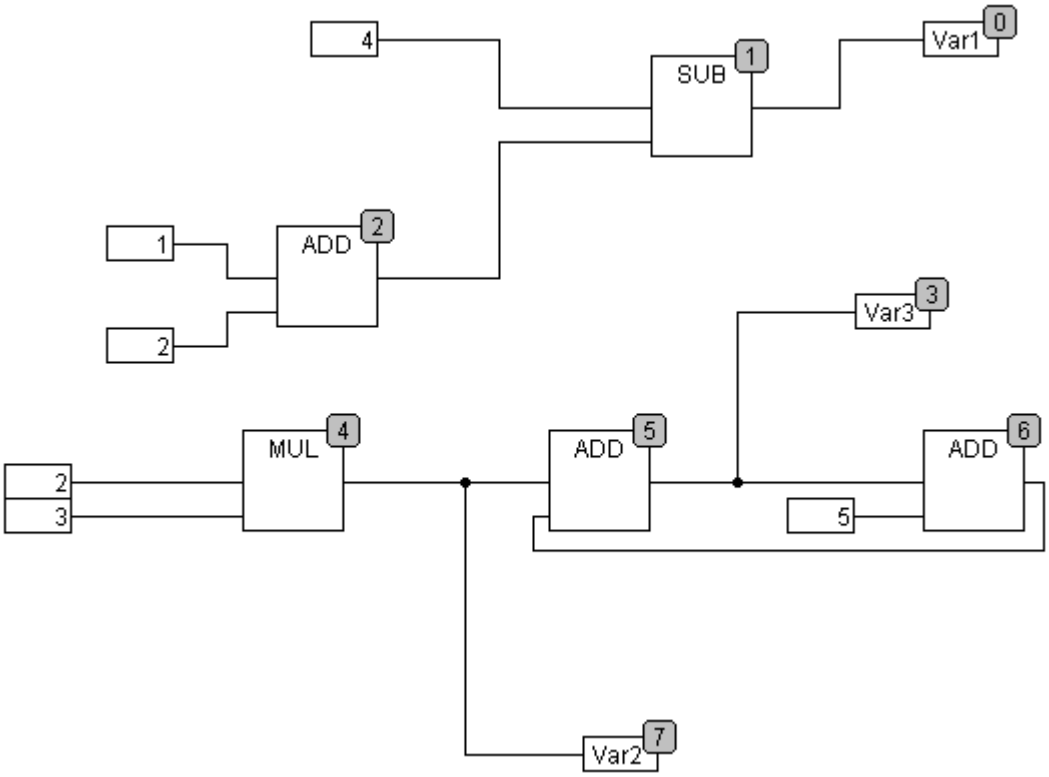
With this command all selected elements will be moved to the end of the sequential processing list whereby the order within the group of selected elements is maintained. The order within the group of unselected elements also remains the same.

5.4.5.30 'Extras' 'Order' 'Order everything according to data flow"

This command **effects all** elements. The order of execution is determined by the data flow of the elements and not by their position.

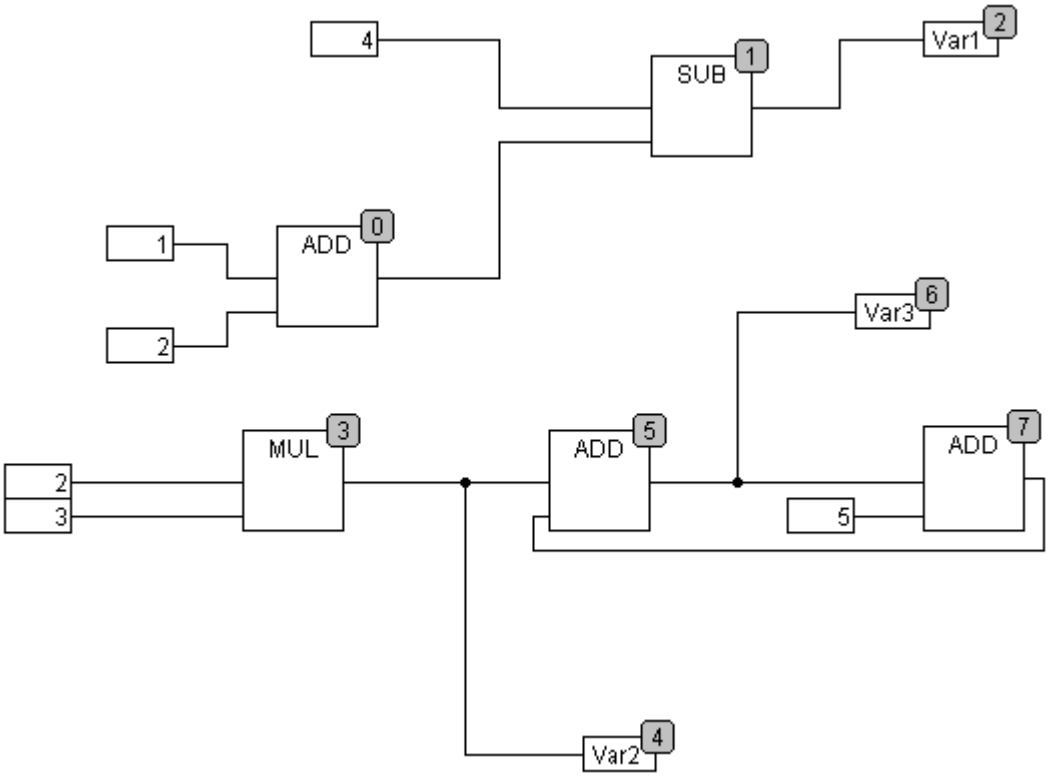
The diagram below shows elements which have been ordered topographically.

X Sequence before the ordering according to data flow



The following arrangement exists after selecting the command:

X Sequence after the ordering according to data flow



When this command is selected the first thing to happen is that the elements are ordered topographically. A new sequential processing list is then created. Based on the known values of the inputs, the computer calculates which of the as yet not numbered elements can be processed next. In the above "network" the block AND, for example, could be processed immediately since the values at its inputs (1 and 2) are known. Block SUB can only then be processed since the result from ADD must be known first, etc.

Feedback paths are inserted last.

The advantage of the data flow sequencing is that an output box which is connected to the output of a block comes immediately after it in the data flow sequencing system which by topological ordering would not always be the case. The topological ordering can deliver another result in some cases than ordering by data flow, a point which one can recognise from the above example.

5.4.5.31 'Extras' 'Create macro"

Symbol:

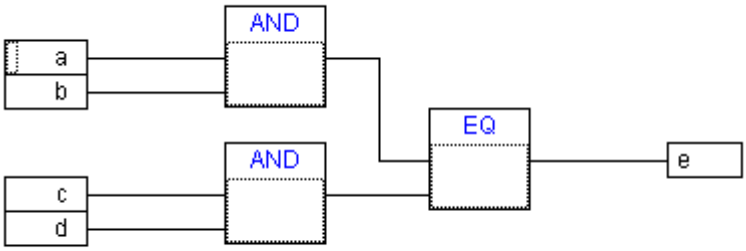
With this command, several POUs that are selected at the same time can be assembled into a block, which can be named as a macro. Macros only can be reproduced by Copy/Paste, whereby each copy becomes a separate macro whose name can be chosen independently. Macros are thus not references. All connections that are cut by the creation of a macro generate in- or out-pins on the macro. Connections to inputs generate an in-pin. The default name appears

next to the pin in the form In<n>. For connections to outputs, Out<n> appears. Affected connections which had connection markers prior to the creation of the macro, retain the connection marker on the PIN of the macro.

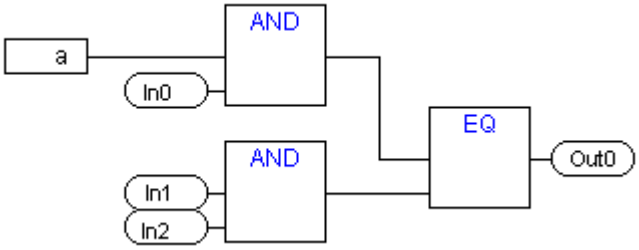
At first, a macro has the default name "MACRO". This can be changed in the Name field of the macro use. If the macro is edited, the name of the macro will be displayed in the title bar of the editor window appended to the POU name.

Example:

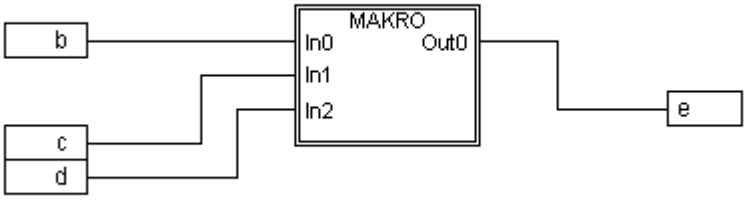
Selection



Macro:



In the editor:



5.4.5.32 'Extras' 'Jump into Macro'

Symbol:

By this command, or by double clicking on the body of the macro, the macro is opened for editing in the editor window of the associated POU. The name of the macro is displayed appended to the POU name in the title bar.

The pin boxes generated for the in- and outputs of the macro during creation can be handled like normal POU in- and outputs. They can also be moved, deleted, added, etc. They differ only in how they are displayed and have no position index. For adding you can use the buttons (input) resp. (output), which are available in the menu bar. Pin boxes have rounded corners. The text in the pin-box matches the name of the pin in the macro display.

The order of the pins in the macro box follows the order of execution of the elements of the macro. A lower order index before a higher one, higher pin before lower.

The processing order within the macro is closed, in other words the macro is processed as a block, at the position of the macro in the primary POU. Commands for manipulating the order of execution therefore operate only within the macro.

5.4.5.33 'Extras' 'Expand macro'

With this command, the selected macro is re-expanded and the elements contained in it are inserted in the POU at the macro's location. The connections to the pins of the macro are again displayed as connections to the in- or outputs of the elements. If the expansion of the macro can not occur at the location of the macro box for lack of space, the macro is displaced to the right and down until enough space is available.

Note:
If the project is saved under project version number 2.1, the macros will likewise all be expanded. All macros will also be expanded before conversion into other languages.

5.4.5.34 'Extras' 'Back one macro level', 'Extras' 'Back all macro level'

Symbols:

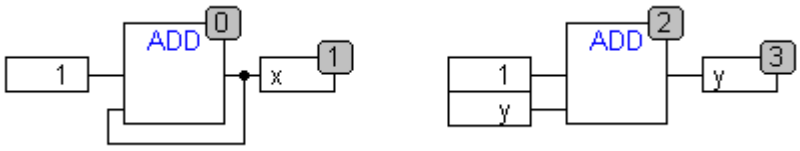
These commands are also available in the toolbar, as soon as a macro is opened for editing. If macros are nested within one another, it is possible to switch to the next higher or to the highest display level.

5.4.5.35 Feedback paths in CFC

Feedback paths can only be displayed directly in the continuous function chart editor and not in the usual function block diagram editor. Here it should be observed that the output of a block always carries an internal intermediate variable. The data type of the intermediate variable results, for operators, from the largest data type of the inputs.

The data type of a constant is obtained from the smallest possible data type, that is the constant '1' adopts the data type SINT. If now an addition with feedback and the constant '1' is executed, the first input gives the data type SINT and the second is undefined because of the feedback. Thus the intermediate variable is also of the type SINT. The value of the intermediate variable is only then allocated to the output variable.

The diagram below shows an addition with feedback and an addition with a variable. The variables x and y should be of the type INT here.



There are differences between the two additions:

The variable y can be initialised with a value which is not equal to zero but this is not the case for intermediate variable for the left addition.

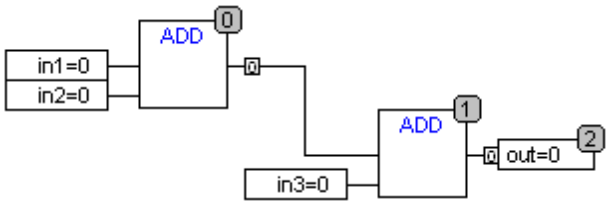
The intermediate variable for the left addition has the data type SINT while that on the right has the data type INT. The variables x and y have different values after the 129th call up. The variable x, although it is of the type INT, contains the value - 127 because the intermediate variable has gone into overflow. The variable y contains the value 129, on the other hand.

5.4.5.36 CFC in Online mode

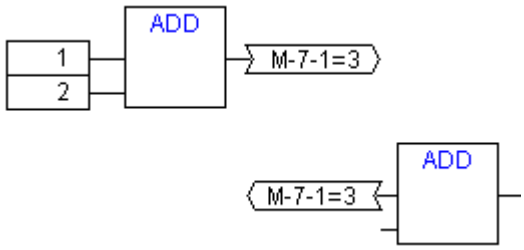
Monitoring:

The values for inputs and outputs are displayed within the input or output boxes. Constants are not monitored. For non-boolean variables, the boxes are expanded to accommodated the values displayed. For boolean connections, the variable name as well as the connection are displayed in blue if the value is TRUE, otherwise they remain black.

Internal boolean connections are also displayed Online in blue in the TRUE state, otherwise black. The value of internal non-boolean connections is displayed in a small box with rounded corners on the output pin of the connection.



PINs in macros are monitored like in- or output boxes.



Non-boolean connections with connection markers display their value within the connection marker. For boolean connections, the lines as well as the marker names are displayed in blue if the line is carrying the value TRUE, otherwise black.

Flow control:

When flow control is switched on, the connections that have been traversed are marked with the color selected in the project options.

Breakpoints:

Breakpoint s can be set on all elements that also have a processing sequence order index. The processing of the program will be halted prior to execution of the respective element, that is for POUs and outputs before the assignment of inputs, for jump labels before execution of the element with the next index. The processing sequence index of the element is used as the breakpoint position in the Breakpoint dialog.

The setting of breakpoints on a selected element is accomplished with the F9 key or via the menu item 'Breakpoint on/off' in the 'Online' or 'Extras' menu or in the editor's context menu. If a breakpoint is set on an element, then this will be erased and reversed the next time the command 'Breakpoint on/off' is executed. In addition, the breakpoint on an element can be toggled by double-clicking on it.

Breakpoints are displayed in the colors entered in the project options.

RETURN label:

In Online mode, a jump label with the name "RETURN" is automatically generated in the first column and after the last element in the editor. This label marks the end of the POU and is jumped to when stepping just before execution leaves the POU. No RETURN marks are inserted in macros.

Stepping:

When using 'Step over' the element with the next-higher order index will always be jumped to. If the current element is a macro or a POU, then its implement branches when 'Step in' is in effect. If a 'Step over' is executed from there, the element whose order index follows that of the macro is jumped to.

6 Overview of the Resources

In the **Resources** register card of the Object Organizer, there are objects for configuring and organizing your project and for keeping track of the values of the variables:

X Resources

6.1 Global Variables

6.1.1 Editing Global Variables

In the Object Organizer, you will find three objects in the **Resources** register card in the **Global Variables** folder (default names of the objects in parentheses).

All variables defined in these objects are recognized throughout the project.

If the global variables folder is not opened up (plus sign in front of the folder), you can open it with a doubleclick <Enter> in the line.

Select the corresponding object. The **'Object Open'** command opens a window with the previously defined global variables. The editor for this works the same way as the declaration editor.

6.1.2 Several Variables Lists

Global variables, and variable configurations (**VAR_CONFIG**) must be defined in separate objects.

If you have declared a large number of global variables, and you would like to structure your global variables list better, then you can create further variables lists.

In the Object Organizer, select the **Global Variables** folder or one of the existing objects with global variables. Then execute the **'Project' 'Object**

Add' command. Give the object that appears in the dialog box a corresponding name. With this name an additional object will be created with the key word **VAR_GLOBAL**. If you prefer an object a variable configuration, change the corresponding key word to **VAR_CONFIG**.

6.1.3 Global Variables

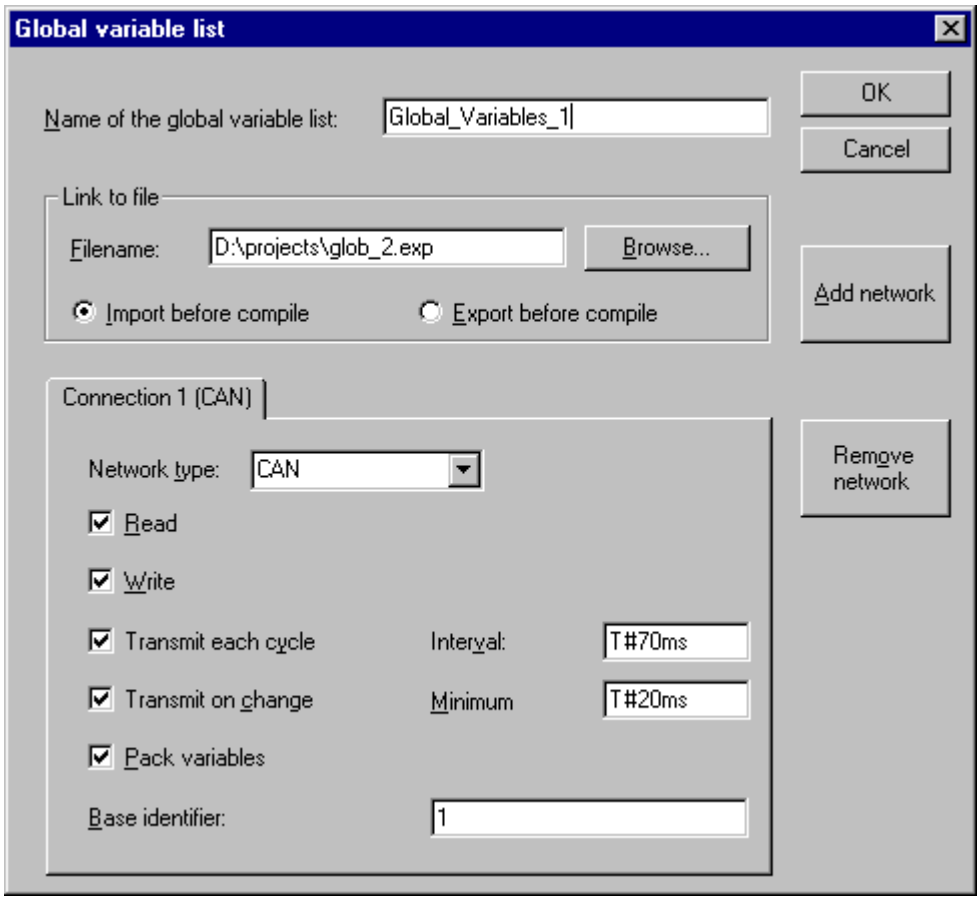
"Normal" variables, constants or remanent variables that are known throughout the project can be declared as global variables.

6.1.3.1 Create a Global Variable List

To create a Global Variable List, open the register 'Resources' in the Object Organizer and select the entry 'Global Variables' or select an already existing list. Then choose the command 'Project' 'Object' 'Add' to open the dialog Global variable list.

This dialog can also be opened by the command 'Project' 'Object' 'Properties' which is available if an existing Global Variable List is marked in the object organizer. It shows the configuration of this list..

X Dialog to create a new Global Variable List



If the option 'Support network variables' is activated in the target settings, then the button <Add network> is available. Pressing this button the dialog gets

extended and looks like shown in the picture. If the option is not activated, the button is not available.

Insert a **Name of the global variable list**. If you have an export file (*.exp) or a DCF file, which contains the desired variables, you can set up a link to this file (**Link to file**). To do this, insert the path of the file in the field **Filename** resp. press the button Browse to get the standard dialog 'Select text file'. DCF files are converted to ICE syntax when they are read in.

Activate option **Import before compile**, if you wish that the variable list will be read from the external file before each compilation of the project. Activate the option **Export before compile**, if you want the variable list to be written to the external file before each compilation of the project.

If no configuration is yet present, you will get in the case of a CAN network a single tabulator sheet with the inscription **'Connection 1 (CAN)'**. Each time the 'Add network' button is pressed again, you get up to four more sheets inscribed with serial numbers after "Connection".

Choose the desired type from the list following **Network type**. The list is defined by the target system entries. For example, "CAN" as an abbreviation for a CAN network, or "UDP" for a UDP transmission system, might be selectable.

The following options can be activated or deactivated in configuring the transmission behavior of the variables:

Read: The variables in the list are read; if the option is deactivated, further variables sent over the net will be ignored.

Write: The variables are written; the following options apply:

Transmit each cycle: Variables are written within the intervals specified after **Interval**. (time notation e.g. T#70ms).

Transmit on change: Variables are written only when their values change; an entry after Minimum can, however, set a minimum time lapse between transfers.

Pack variables: The variables are assembled for transfer into packets whose size depends on the network. If the option is deactivated, a packet is set up for each variable.

Base identifier: The packets in which the variables are sent are given an identification number which in the standard case begins with 1 and is assigned in rising order, so long as you do not enter another starting number here.

6.1.3.2 Editing Global Variable Lists

The editor for global variables works similar to the declaration editor. But note that you cannot edit in this editor an list, which is an image of an linked

external variable list ! External variable lists only can be edited externally and they will be read at each opening and compiling of the project.

Syntax:

```
VAR_GLOBAL

      (* Variables declarations *)

END_VAR
```

6.1.3.3 Editing Remanent Global Variables Lists

If they are supported by the runtime system, remanent variables may be processed. There are two types of remanent global variables:

Retain variables remain unchanged after an uncontrolled shutdown of the runtime system (off/on) or an 'Online' 'Reset' in **WAGO-I/O-*PRO* 32**.
Persistent variables remain unchanged after a controlled shutdown of the runtime system (stop, start) or an 'Online' 'Cold reset' or a download.

Persistent variables are not automatically also Retain variables !

Remanent variables are additionally assigned the keyword **RETAIN** or **PERSISTENT**.

Network variables are also defined in this syntax.

Syntax:

```
VAR_GLOBAL RETAIN

      (* Variables declarations *)

END_VAR

VAR_GLOBAL PERSISTENT

      (* Variables declarations *)

END_VAR
```

6.1.4 Global Constants

Global constants additionally get the keyword **CONSTANT.**

Syntax:

```
VAR_GLOBAL CONSTANT

      (* Variables declarations *)

END_VAR
```

6.2 Variable Configuration

In function blocks it is possible to specify addresses for inputs and outputs that are not completely defined, if you put the variable definitions between the key words **VAR** and **END_VAR**. Addresses not completely defined are identified with an asterisk.

Example:

```
FUNCTION_BLOCK locio

VAR
      loci AT %I*: BOOL := TRUE;
      loco AT %Q*: BOOL;

END_VAR
```

Here two local I/O-variables are defined, a local-In (%I*) and a local-Out (%Q*).

If you want to configure local I/Os for variables configuration in the Object Organizer in the **Resources** register card, the object **Variable_Configuration** will generally be available. The object then can be renamed and other objects can be created for the variables configuration.

The editor for variables configuration works like the declaration editor.

Variables for local I/O-configurations must be located between the key words **VAR_CONFIG** and **END_VAR**.

The name of such a variable consists of a complete instance path through which the individual POUs and instance names are separated from one another by periods. The declaration must contain an address whose class (input/output) corresponds to that of the incompletely specified address (%I*, %Q*) in the function block. Also the data type must agree with the declaration in the function block.

Configuration variables, whose instance path is invalid because the instance does not exist, are also denoted as errors. On the other hand, an error is also reported if no configuration exists for an instance variable. In order to receive a list of all necessary configuration variables, the "All Instance Paths" menu item in the 'Insert' menu can be used.

X Example

Assume that the following definition for a function block is given in a program:

```
PROGRAM PLC_PRG
```

```
VAR
      Hugo: locio;
      Otto: locio;

END_VAR
```

Then a corrected variable configuration would look this way:

```
VAR_CONFIG
      PLC_PRG. Hugo.loci AT %IX1.0 : BOOL;
      PLC_PRG. Hugo.loco AT %QX0.0 : BOOL;
      PLC_PRG. Otto.loci AT %IX1.0 : BOOL;
      PLC_PRG.Otto.loco AT %QX0.3 : BOOL;

END_VAR
```

6.2.1 ‚Insert' 'All Instance Paths'

With this command a **VAR_CONFIG - END_VAR**-block is generated that contains all of the instance paths available in the project. Declarations already on hand do not need to be reinserted in order to contain addresses already in existence. This menu item can be found in the window for configuration of variables if the project is compiled ('Project' 'Rebuild All').

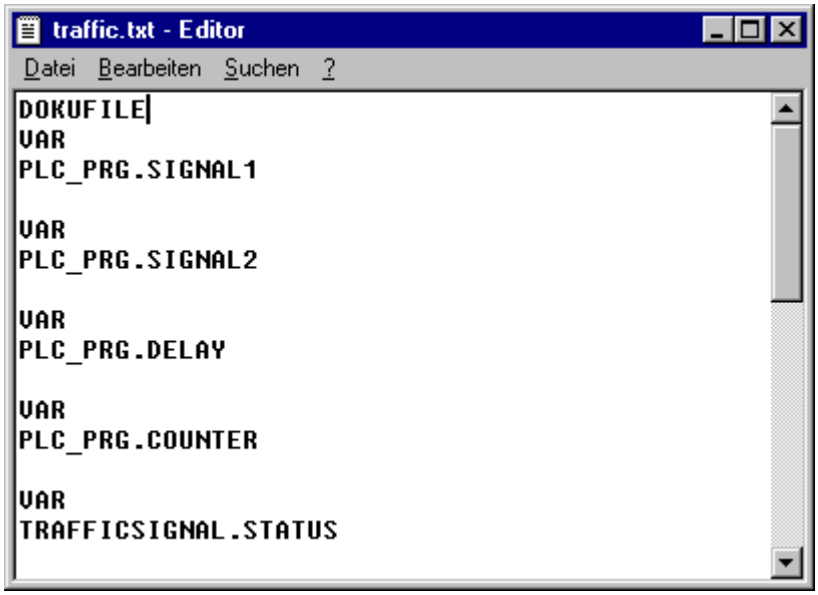
6.2.2 Document Frame

6.2.2.1 Document Frame

If a project is to receive multiple documentations, perhaps with German and English comments, or if you want to document several similar projects that use the same variable names, then you can save yourself a lot of work by creating a docuframe with the 'Extras' 'Make Docuframe File' command.

The created file can be loaded into a desired text editor and can be edited. The file begins with the **DOCUFILE** line. Then a listing of the project variables follows in an arrangement that assigns three lines to each variable: a **VAR** line that shows when a new variable comes; next, a line with the name of the variable; and, finally, an empty line. You can now replace this line by using a comment to the variable. You can simply delete any variables that you are unable to document. If you want, you can create several document frames for your project.

X Windows Editor with Document Frame



In order to use a document frame, give the 'Extras' 'Link Docu File' command. Now if you document the entire project, or print parts of your project, then in the program text, there will be an insertion of the comment produced in the docuframe into all of the variables. This comment only appears in the printout!

6.2.2.2 'Extras' 'Make Docuframe File'

Use this command to create a document frame. The command is at your disposal, whenever you select an object from the global variables.

A dialog box will open for saving files under a new name. In the field for the **name file**, the *.txt extension has already been entered. Select a desired name. Now a text file has been created in which all the variables of your project are listed.

6.2.2.3 'Extras' 'Link Docu File'

With this command you can select a document frame.

The dialog box for opening files is opened. Choose the desired document frame and press **OK**. Now if you document the entire project, or print parts of your project, then in the program text there will be an insertion of the comment produced in the docuframe into all of the variables. This comment only appears in the printout!

To create a document frame, use the 'Extras' 'Make Docuframe File' command.

6.3 PLC Browser

The PLC-browser is a text-based control monitor (terminal). Commands for the request of specific information from the controller are entered in an entry line and sent as string to the controller. The returned response string is displayed in a result window of the browser. This functionality serves diagnostic- and debugging purposes.

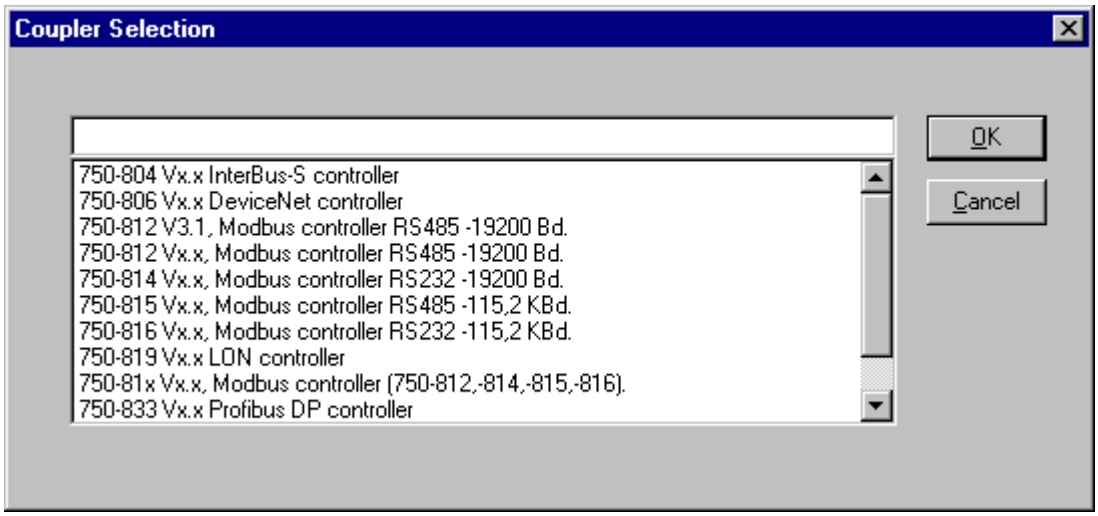
The available comands and functions are depending on the target system

6.4 PLC Configuration

The PLC Configuration is found as an object in the register card **Resources** in the Object Organizer. With the PLC Configuration editor, you can describe the I/O-modules connected to the hardware the opened project is established for. In **WAGO-I/O-*PRO* 32** these entries are used for information and the selection of the connected controller is done with the menu ***Extras*** \ ***PLC Selection***.

6.4.1 PLC Selection

The selection of the connected controller is done with the menu ***Extras*** \ ***PLC Selection***.
All available controllers are shown in a selection list. This list is shown automatically when you login without selecting a controller before.


Coupler Selection
OK
Cancel
750-804 Vx.x InterBus-S controller
750-806 Vx.x DeviceNet controller
750-812 V3.1, Modbus controller RS485 -19200 Bd.
750-812 Vx.x, Modbus controller RS485 -19200 Bd.
750-814 Vx.x, Modbus controller RS232 -19200 Bd.
750-815 Vx.x, Modbus controller RS485 -115,2 KBd.
750-816 Vx.x, Modbus controller RS232 -115,2 KBd.
750-819 Vx.x LON controller
750-81x Vx.x, Modbus controller (750-812,-814,-815,-816).
750-833 Vx.x Profibus DP controller

The selection is accepted with **OK** or aborted with **CANCEL**.

6.5 Task Configuration

In addition to declaring the special PLC_PRG program, you can also control the processing of your project using the task management.

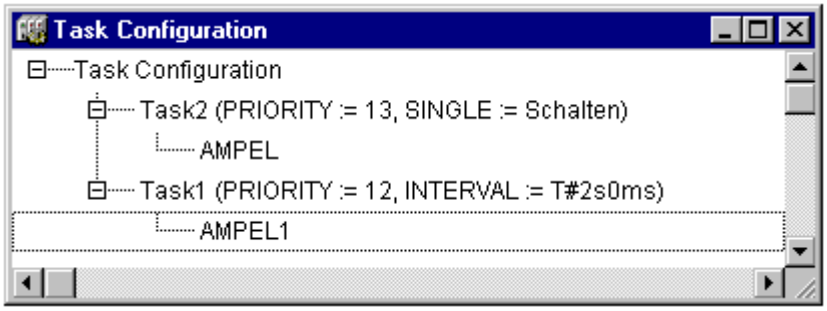
The Task Configuration is found as an object in the **Resources** register card in the Object Organizer. The task editor contains a series of tasks. The task declaration consists of the name of the task, an entry for the priority the task is to have, and an entry for the condition under which the task is to be executed. This requirement can either be a time interval, according to which the task is to be executed, or a global variable, in the event it has a rising edge, brings about an execution.

For each task you can now specify a series of programs that will be started by the task. If the task is executed in the present cycle, then these programs will be processed the length of one cycle.

The Task Configuration is displayed in the following form:

- The Task Configuration is located in the first line.
- Underneath and indented from the Task Configuration, you will find a sequence of task entries (with name, priority, interval, and occurrence).
- Below each task entry, there is again a series of program call ups.

x Example for a Task Configuration



In this example of a Task Configuration, Task2 has a lower priority than Task1. Task1, however, is only executed every two seconds. (The entry under Single is disregarded.) Thus, in this Task Configuration, Task1 is executed every two seconds, and, in between, Task2 can be executed at any time, provided that the global variable "Schalten" has a rising edge.

6.5.1 Which task is being processed?

- For the execution, the following rules apply:
- That task is executed, whose condition has been met; i.e., its specified time has expired, or after its condition variable exhibits a rising edge.
- If several tasks have a valid requirement, then the task with the highest priority will be executed.
- If several tasks have valid conditions and equivalent priorities, then the task that has had the longest waiting time will be executed first.
- The most important commands are found in the context menu (right mouse button or **<Ctrl>+<F10>**).

6.5.2 Working in the Task Configuration

- At the heading of the Task Configuration are the words "Task Configuration." If a plus sign is located before the words, then the sequence list is closed. By doubleclicking on the list or pressing <Enter>, you can open the list. A minus sign now appears. By doubleclicking once more, you can close the list again.
- For every task, there is a list of program call-ups attached. Likewise, you can open and close this list the same way.
- With the 'Insert' 'Insert Task' command, you can insert a task.
- With the 'Insert' 'Insert Program Call', a program call will be inserted.

- With the 'Extras' 'Edit Entry' command, you can edit the task characteristics or the program call-up, depending on the selected element.
- By clicking on the task or program name, or by pressing the <Space bar>, you can set an edit control box around the name. Then you can change the designation directly in the task editor.

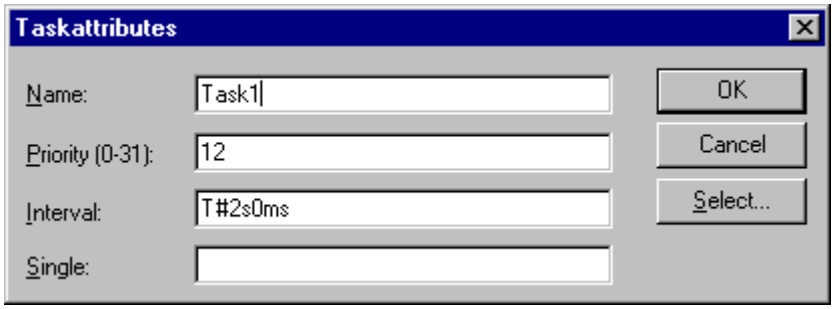
6.5.3 'Insert' 'Insert Task' or 'Insert' 'Append Task'

With this command you can insert a new task into the Task Configuration.

If a task is selected, then the **'Insert Task'** command will be at your disposal. The new task will be inserted in front of the cursor. If the words Task Configuration are selected, then the **'Append Task'** is available, and the new task will be appended to the end of the existing list.

The dialog box will open for you to set the task attributes.

X Dialog Box for Setting Task Attributes



In the dialog box you can enter the desired attributes: the **Name**; the **Priority** (a number between 0 and 31, with the following validities: 0 has the highest, and, 31, the lowest priority); the **Interval** after which the task should be started again; or a variable that, following a raising edge, will cause an execution of the task (in the **Single** field). With the **Select...** button, you can open the Input Assistant to select from the declared variables.

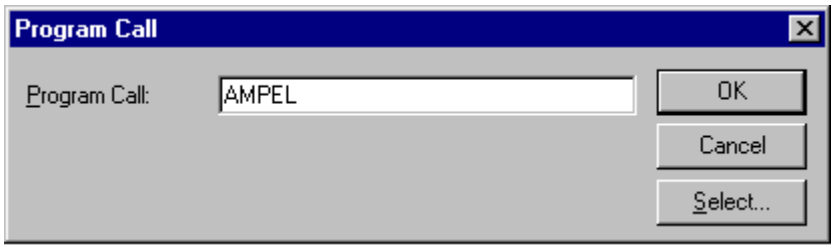
If an entry is on hand for both the interval and for the variable, then only the interval time will be considered for the execution requirement. If an entry has not been made in either of the two fields, then the execution intervall is depending on which target system is used (see the specific runtime system documentation; e.g. an interval of 10 ms is set by the runtime **WAGO-I/O-*PRO* 32**SP NT V2.2).

6.5.4 'Insert' 'Insert Program Call' or 'Insert' 'Append Program Call'

With these commands you will open the dialog box for entering a program call to a task in the Task Configuration.

With **'Insert Program Call'**, the new program call is inserted in front of the cursor, and with **'Append Program Call'**, the program call is appended to the end of the existing list.

X Dialog box for Program Call Entry



In the field, specify a valid program name for your project, or open the Input Assistant with the **Select** button to select a valid program name. If the selected program requires input variables, then enter these in their usual form and of the declared type (for example, prg(invar:=17)).

6.5.5 'Extras' 'Edit Entry'

Depending on the element selected, you can use this command in the Task Configuration to open either the dialog box for setting the task attributes (see 'Insert' 'Task') or the dialog box for entering the program call (see 'Insert' 'Program Call').

If the cursor is located at the task entry, and there is no list of program calls appended to the task entry, then you open the dialog for setting the doubleclicking on the entry or by pressing <Enter>.

If the cursor is located on an entry for a program call, then you can also open the dialog box for editing the program entry by doubleclicking on the entry.

By clicking on the task or program name, or by pressing the <Space bar>, you can set an edit control box around the name. Then, you can change the designation directly in the task editor.

6.5.6 'Extras' 'Set Debug Task'

With this command a debugging task can be set in Online mode in the Task Configuration. The text [DEBUG] will appear after the set task.

The debugging capabilities apply, then, only to this task. In other words, the program only stops at a breakpoint if the program is gone through by the set task.

6.6 Sampling Trace

Sample tracing means that the progression of values for variables is traced over a certain time frame. These values are written in a ring buffer (trace buffer). If the memory is full, then the "oldest" values from the start of the memory will be overwritten. As a maximum, 20 variables can be traced at the same time. A maximum of 500 values can be traced per variable.

Since the size of the trace buffer in the PLC has a fixed value, in the event of very many or very wide variables (DWORD), fewer than 500 values can be traced.

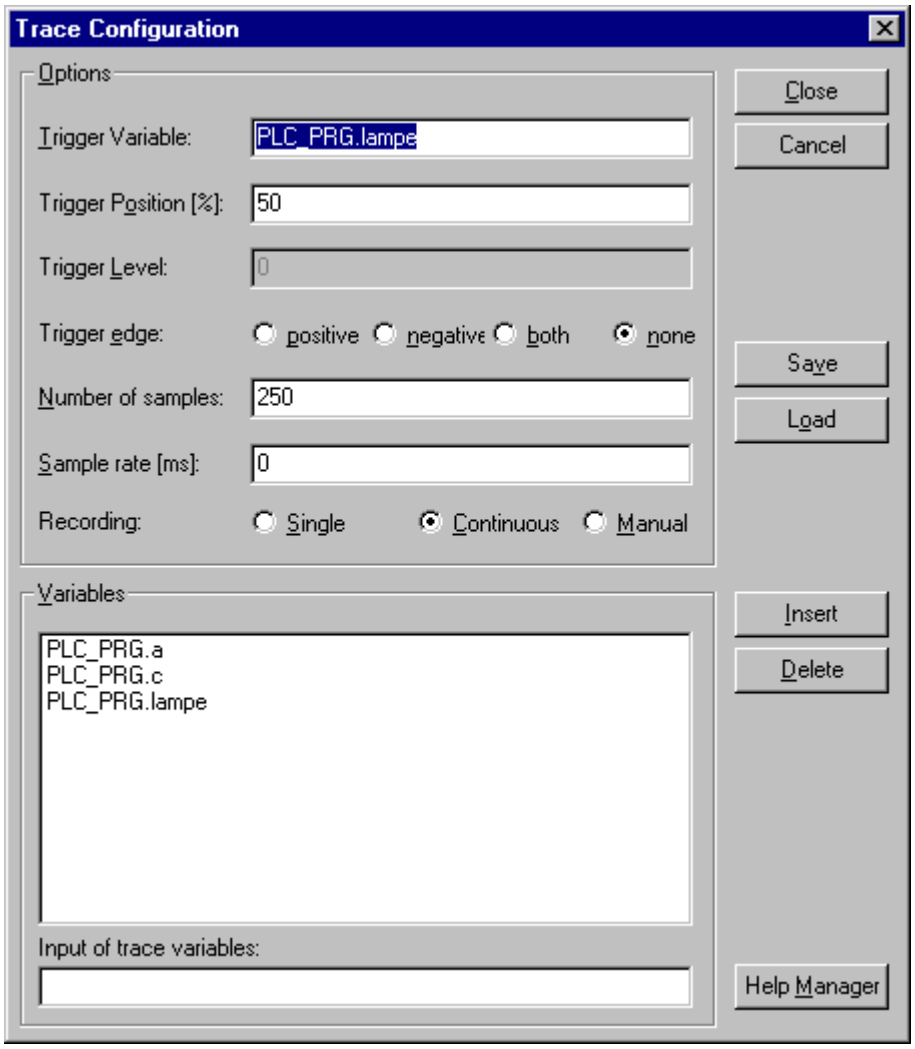
Example: if 10 WORD variables are traced and if the memory in the PLC is 5000 bytes long, then, for every variable, 250 values can be traced.

In order to be able to perform a trace, open the object for **a** **Sampling Trace** in the **Resources** register card in the Object Organizer. After this, you must enter the trace variables to be traced. (See 'Extras' 'Trace Configuration'.) After you have sent the configuration with '**Save Trace'** to the PLC and have started the trace in the PLC ('Start Trace'), then the values of the variables will be traced. With 'Read Trace', the final traced values will be read out and displayed graphically as curves.

6.6.1 'Extras' 'Trace Configuration'

With this command you will be given the dialog box for entering the variables to be traced, as well as diverse trace parameters for the Sampling Trace. The dialog can also be opened by a double click in the grey area of the dialog Sampling Trace.

X Dialog Box for Trace Configuration



The list of the **Variables** to be traced is initially empty. In order to append a variable the variable must be entered in the field under the list. Following this, you can use the **Add** button or the <Enter> to append the variable to the list. You can also use the Input Assistant.

A variable is deleted from the list when you select the variable and then press the **Delete** button.

A Boolean or analogue variable can be entered into the field **Trigger Variable**. The input assistance can also be used here. The trigger variable describes the termination condition of the trace. In **Trigger Level** you enter the level of an analogue trigger variable at which the trigger event occurs. When **Trigger edge positive** is selected the trigger event occurs after an ascending edge of the Boolean trigger variable or when an analogue variable has passed through the trigger level from below to above. **Negative** causes triggering after a descending edge or when an analogue variable went from above to below. **Both** causes triggering for both descending and ascending edges or by a positive or negative pass, whereas **none** does not initiate a triggering event at all. **Trigger Position** is used to set the percentage of the measured value which will be recorded before the trigger event occurs. If, for example, you enter 25 here then 25 % of the measured values are shown

before the triggering event and 75% afterwards and then the trace is terminated. The field **Sample Rate** is used set the time period between two recordings in milliseconds. The default value "0" means one scanning procedure per cycle.

Select the mode for recalling the recorded values: With **Single** the **Number of** the defined **samples** are displayed one time. With **Continuous** the reading of the recording of the defined number of measured values is initiated anew each time. If, for example, you enter the number '35' the first display contains the first measured values 1 to 35 and the recording of the next 35 measured values (36-70) will then be automatically read, etc.. **Manual** selection is used to read the trace recordings specifically with 'Extras' 'Read trace'.

The recall mode functions independently of whether a trigger variable is set or not. If no trigger variable is set the trace buffer will be filled with the defined number of measured values and the buffer contents will be read and displayed on recall.

The button **Save** is used to store the trace configuration which has been created in a file. The standard window "File save as" is opened for this purpose.

Stored trace configurations can be retrieved using the button **Load**. The standard window "File open" is opened for this purpose.

Note:
Please note that **Save** and **Load** in the configuration dialog only relates to the configuration, not to the values of a trace recording (in contrast to the menu commands 'Extras' 'Save trace' and 'Extras' 'Load trace').

If the field Trigger Variable is empty, the trace recording will run endlessly and can be stopped by 'Extras' 'Stop Trace'.

6.6.2 'Extra' 'Start Trace'

Symbol:

With this command the trace configuration is transferred to the PLC and the trace sampling is started in the PLC.

6.6.3 'Extra' 'Read Trace'

Symbol:

With this command the present trace buffer is read from the PLC, and the values of the selected variables are displayed.

6.6.4 'Extra' 'Auto Read'

With this command the present trace buffer is read automatically from the PLC, and the values are continuously displayed.

If the trace buffer is automatically read, then a check (✓) is located before the menu item.

6.6.5 'Extra' 'Stop Trace'

Symbol:

This command stops the Sampling Trace in the PLC.

6.6.6 Selection of the Variables to be Displayed

The comboboxes to the right, next to the window for displaying curves trace variables defined in the trace configuration. If a variable is selected from the list, then after the trace buffer has been read the variable will be displayed in the corresponding color (Var 0 green, etc.). Variables can also be selected if curves are already displayed.

A maximum of up to eight variables can be observed simultaneously in the trace window.

6.6.7 Display of the Sampling Trace

X Sampling Trace of Different Variables

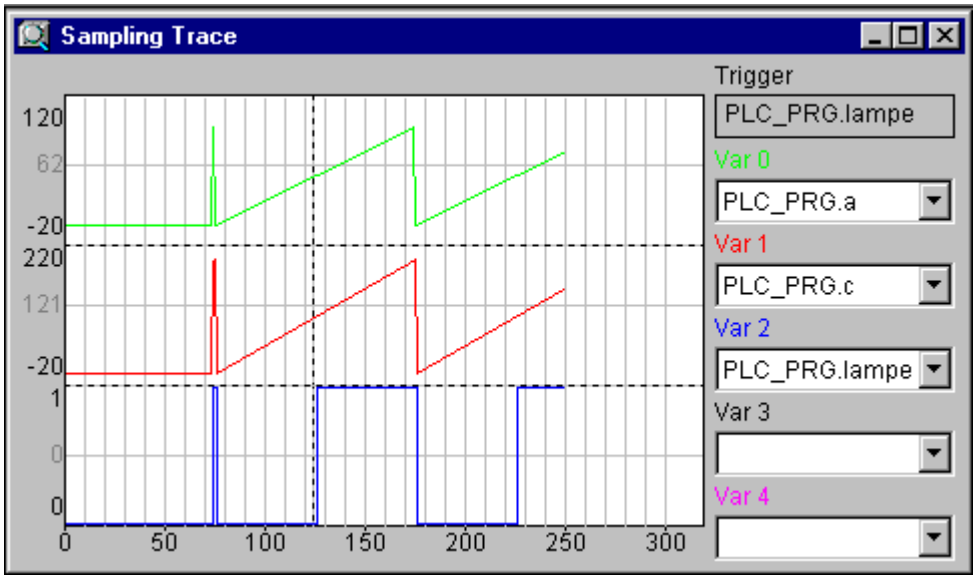
If a trace buffer is loaded, then the values of all variables to be displayed will be read out and displayed. If no scan frequency has been set, then the X axis will be inscribed with the continuous number of the traced value. The status indicator of the trace window (first line) indicates whether the trace buffer is full and when the trace is completed.

If a value for the scan frequency was specified, then the x axis will specify the time of the traced value. The time is assigned to the "oldest" traced value. In the example, e.g., the values for the last 25 seconds are indicated.

The Y axis is inscribed with values in the appropriate data type. The scaling is laid out in a way that allows the lowest and the highest value to fit in the viewing area. In the example, Var 0 has taken on the lowest value of 6, and the highest value of 100: hence the setting of the scale at the left edge.

If the trigger requirement is met, then a vertical dotted line is displayed at the interface between the values before and after the appearance of the trigger requirement.

A memory that has been read will be preserved until you change the project or leave the system.



6.6.8 'Extras' 'Cursor Mode'

The easiest way to set a cursor in the monitoring area is to click there with the left mouse button. A cursor appears and can be moved by the mouse. At the top of the monitoring window the current x-position of the cursor is displayed. In the fields next to 'Var 0', 'Var 1', ..., 'Var n' the value of the respective variable is shown.

Another way is the command 'Extras' 'Cursor mode'. With this command two vertical lines will appear in the Sampling Trace. First they are laying one on the other. One of the lines can be moved to the right or to the left by the arrow keys. By pressing **<Ctrl>+<left>** or **<Ctrl>+<right>** the speed of the movement can be increased by factor 10.

If additionally the <Shift> key is pressed, the second line can be moved, showing the difference to the first one.

6.6.9 'Extras' 'Multi Channel'

With this command you can alternate between single-channel and multi-channel display of the Sampling Trace. In the event of a multi-channel display, there is a check (✓) in front of the menu item.

The multi-channel display has been preset. Here the display window is divided into as many as eight display curves. For each curve the maximum and the minimum value are displayed at the edge.

In a single-channel display, all curves are displayed with the same scaling factor and are superimposed. This can be useful when displaying curve abnormalities.

6.6.10 'Extras' 'Show grid'

With this command you can switch on and off the grid in the graphic window. When the grid is switched on, a check (✓) will appear next to the menu item.

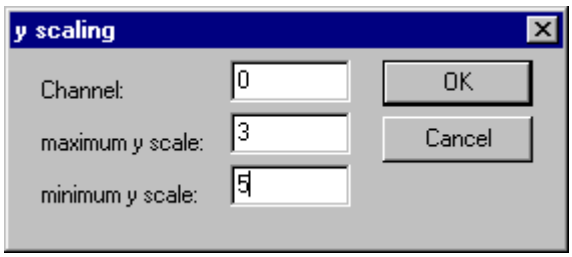
6.6.11 'Extras' 'Y Scaling'

With this command you can change the preset Y scaling of a curve in the trace display.

In the dialog box specify the number of the desired curve (**Channel**) and the new maximum (**maximum y scale**) and the new minimum value (**minimum y scale**) on the y axis.

By doubleclicking on a curve you will also be given the dialog box. The channel and the former value are preset.

X Dialog Box for Setting the Y Scale



6.6.12 'Extras' 'Stretch'

Symbol:

With this command you can stretch (zoom) the values of the Sampling Trace that are shown. The beginning position is set with the horizontal picture adjustment bar. With repeated stretches that follow one-after-another, the trace section displayed in the window will increasingly shrink in size.

This command is the counterpart to 'Extras' 'Compress'.

6.6.13 'Extras' 'Compress'

Symbol:

With this command the values shown for the Sampling Trace are compressed; i.e., after this command you can view the progression of the trace variables within a larger time frame. A multiple execution of the command is possible.

This command is the counterpart to 'Extras' 'Stretch'.

6.6.14 'Extras' 'Save Trace'

With this command you can save a Sampling Trace (values + configuration data). The dialog box for saving a file is opened. The file name receives the extension "*.trc".

Be aware, that here you save the traced values as well as the trace configuration, whereas **Save trace** in the configuration dialog only concerns the configuration data.

The saved Sampling Trace can be loaded again with 'Extras' 'Load Trace'.

6.6.15 'Extras' 'Load Trace'

With this command a saved Sampling Trace (traced values + configuration data)can be reloaded. The dialog box for opening a file is opened. Select the desired file with the "*.trc" extension.

With 'Extras' 'Save Trace' you can save a Sampling Trace.

6.6.16 'Extras' 'Trace in ASCII-file'

With this command you can save a Sampling Trace in an ASCII-file. The dialog box is opened for saving a file. The file name receives the extension "*.txt". The values are deposited in the file according to the following scheme:

```
WAGO-I/O-PRO 32 Trace

D:\WAGO-I/O-PRO 32\PROJECTS\TRAFFICSIGNAL.PRO

Cycle PLC_PRG.COUNTER PLC_PRG.LIGHT1

0 2 1

1 2 1

2 2 1

.....
```

If no frequency scan was set in the trace configuration, then the cycle is located in the first column; that means one value per cycle has been recorded at any given time. In the other respects, the entry here is for the point in time in ms at which the values of the variables have been saved since the Sampling Trace has been run.

In the subsequent columns, the corresponding values of the trace variables are saved. At any given time the values are separated from one another by a blank space.

The appertaining variable names are displayed next to one another in the third line, according to the sequence (PLC_PRG.COUNTER, PLC_PRG.LIGHT1).

6.7 Watch and Receipt Manager

6.7.1 Watch and Receipt Manager

With the help of the Watch and Receipt Manager you can view the values of selected variables. The Watch and Receipt Manager also makes it possible to preset the variables with definite values and transfer them as a group to the PLC ('Write Receipt'). In the same way, current PLC values can be read into and stored in the Watch and Receipt Manager ('Read Receipt'). These functions are helpful, for example, for setting and entering of control parameters.

All watch lists created ('Insert' 'New Watch List') are indicated in the left column of the Watch and Receipt Manager. These lists can be selected with a mouse click or an arrow key. In the right area of the Watch and Receipt Manager the variables applicable at any given time are indicated.

In order to work with the Watch and Receipt Manager, open the object for the **Watch and Receipt Manager** in the **Resources** register card in the Object Organizer.

6.7.2 Watch and Receipt Manager in the Offline Mode

In *Offline Mode*, you can create several watch lists in the Watch and Receipt Manager using the 'Insert' 'New Watch List'.

For inputting the variables to be watched, you can call up a list of all variables with the Input Assistant, or you can enter the variables with the keyboard, according to the following notation:

<POUName>.<Variable Name>

With global variables, the POU Name is left out. You begin with a point. The variable name can, once again, contain multiple levels. Addresses can be entered directly.

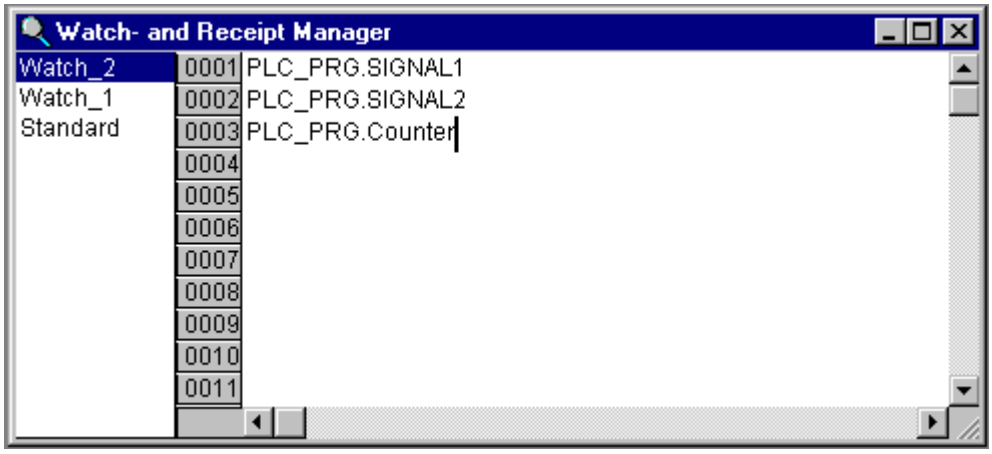
Example of a multiple-level variable:

```
PLC_PRG.Instance1.Instance2.Structure.Componentname
```

Example of a global variable:

```
.global1.component1
```

X Watch and Receipt Manager in the Offline Mode



The variables in the watch list can be preset with constant values. That means that in Online mode you can use the 'Extras' 'Write Receipt' command to write these values into the variables. To do to do must use := to assign the constant value of the variable:

Example:

```
PLC_PRG.TIMER:=50
```

In the example, the PLC_PRG.COUNTER variable is preset with the value 6

6.7.3 'Insert' 'New Watch List'

With this command a new watch list can be inserted into the Watch and Receipt Manager. Enter the desired name for the watch list in the dialog box that appears.

6.7.4 'Extras' 'Rename Watch List'

With this command you can change the name of a watch list in the Watch and Receipt Manager.

In the dialog box that appears, enter the new name of the watch list.

6.7.5 'Extras' 'Save Watch List'

With this command you can save a watch list. The dialog box for saving a file is opened. The file name is preset with the name of the watch list and is given the extension "*.wtc".

The saved watch list can be loaded again with 'Extras' 'Load Watch List'.

6.7.6 'Extras' 'Load Watch List'

With this command you can reload a saved watch list. The dialog box is opened for opening a file. Select the desired file with the "*.wtc" extension. In the dialog box that appears, you can give the watch list a new name. The file name is preset without an extension.

With 'Extras' 'Save Watch List', you can save a watch list.

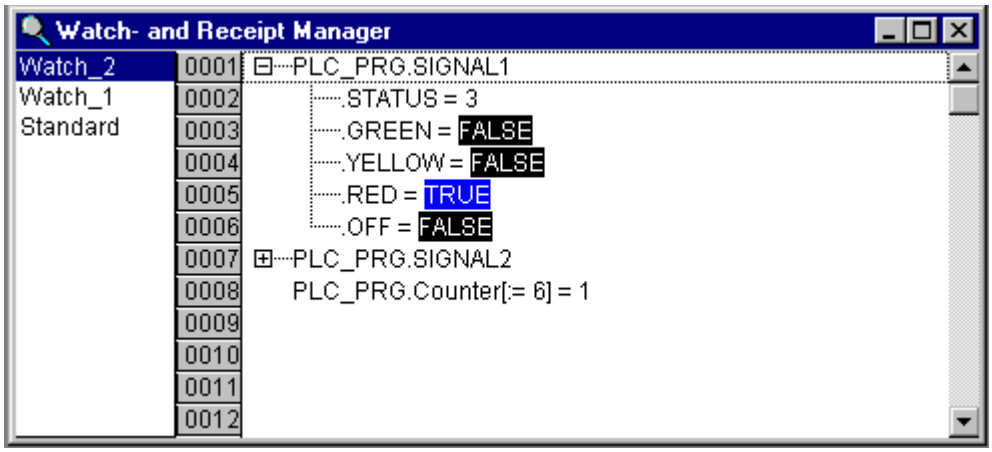
6.7.7 Watch and Receipt Manager in the Online Mode

In Online mode, the values of the entered variables are indicated.

Structured values (arrays, structures, or instances of function blocks) are marked by a plus sign in front of the identifier. By clicking the plus sign with the mouse or by pressing <Enter>, the variable is opened up or closed.If a function block variable is marked in the watch list, the associated context menu is expanded to include the two menu items 'Zoom' and 'Open instance'.

In order to input new variables, you can turn off the display by using the 'Extras' 'Active Monitoring' command. After the variables have been entered, you can use the same command again to activate the display of the values.

X Watch and Receipt Manager in the Online Mode



In the Offline Mode you can preset variables with constant values (through inputting := <value> after the variable). In the Online Mode, these values can now be written into the variables, using the 'Extras' 'Write Receipt' command.

With the 'Extras' 'Read Receipt' command you can replace the presetting of the variable with the present value of the variable.

Note:
Only those values the watch list are loaded which was selected in the Watch and Receipt Manager!

6.7.8 'Extra' 'Monitoring Active'

With this command at the Watch and Receipt Manager in the Online mode, the display is turned on or off. If the display is active, a check (✓) will appear in front of the menu item.

In order to enter new variables or to preset a value (see Offline Mode), the display must be turned off through the command. After the variables have

been entered, you can use the same command again to activate the display of the values.

6.7.9 'Extras' 'Write Receipt'

With this command in the *Online Mode* of the Watch and Receipt Manager you can write the preset values (see Offline Mode) into the variables.

Note:
Only those values of the watch list are loaded which was selected in the Watch and Receipt Manager!

6.7.10 'Extras' 'Read Receipt'

With the command, in the *Online Mode* of the Watch and Receipt Manager, you can replace the presetting of the variables (see Offline Mode) with the present value of the variables.

Example:

```
PLC_PRG.Counter [:= <present value>] = <present value>
```

Note:
Only the values of that watch list are loaded which was selected in the Watch and Receipt Manager!

6.7.11 Force values

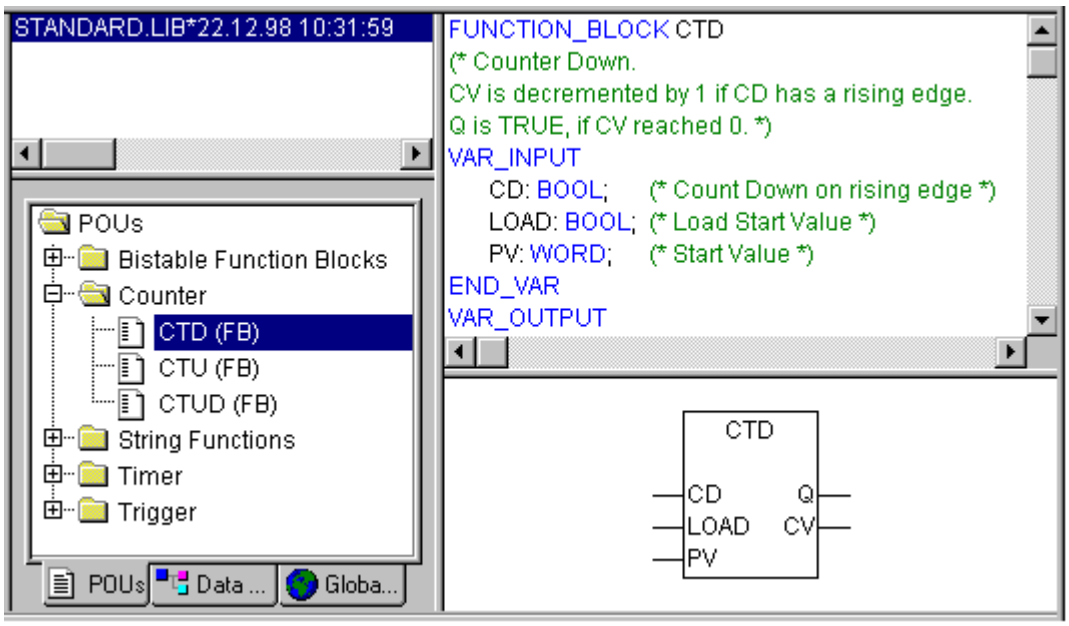
In the Watch and Receipt Manager you can also **'Force values'** and **'Write values'**. If you click on the respective variable value, then a dialog box opens, in which you can enter the new value of the variable. Changed variables appear in red in the Watch and Receipt Manager.

7 Library Manager

The library manager shows all libraries that are connected with the current project. The POUs, data types, and global variables of the libraries can be used the same way as user-defined POUs, data types, and global variables.

The library manager is opened with the **'Window' 'Library Manager'** command. Information concerning included libraries is stored with the project.

X Library Manager



7.1 Using the Library Manager

The window of the library manager is divided into three or four areas by screen dividers. The libraries attached to the project are listed in the upper left area.

In the area below that, depending on which register card has been selected, there is a listing of the **POUs , Data types, Visualizations** or **Global variables** of the library selected in the upper area.

Folders are opened and closed by doubleclicking the line or pressing <Enter>. There is a plus sign in front of closed folders, and a minus sign in front of opened folders.

If a POU is selected by clicking the mouse or selecting with the arrow keys then the declaration of the POU will appear in the upper right area of the library manager; and in the lower right is the graphic display in the form of a black box with inputs and outputs.

With data types and global variables, the declaration is displayed in the right area of the library manager.

7.2 Standard Library

The library with "standard.lib" is always available. It contains all the functions and function blocks which are required from the IEC61131-3 as standard POUs for an IEC programming system. The difference between a standard function and an operator is that the operator is implicitly recognized by the programming system, while the standard POUs must be tied to the project (standard.lib).

The code for these POUs exists as a C-library and is a component of **WAGO-I/O-PRO 32**.

7.3 User-defined Libraries

If a project is to be compiled in its entity and without errors, then it can be saved in a library with the **'Save as'** command in the **'File'** menu. The project itself will remain unchanged. An additional file will be generated, which has the default extension ".lib". This library afterwards can be used and accessed like e.g. the standard library.

For the purpose to have available the POUs of a project in other projects, save the project as an **Internal Library *.lib**. This library afterwards can be inserted in other projects using the library manager.

If you have implemented POUs in other programming languages, e.g. C, and want to get them into a library, then save the project using data type **External Library *.lib)**. You will get the library file but additonally a file with the extension "*.h". This file is structured like a C header file and contains the declarations of all POUs, data types and global variables, which are available with the library. If an external library is used in a project, then in simulation mode that implementation of the POUs will be executed, which was written with **WAGO-I/O-*PRO* 32**; but on the target the C-written implementation will be processed.

7.4 'Insert' 'Additional Library'

With this command you can attach an additional library to your project.

When the command is executed, the dialog box for opening a file appears. Choose the desired library with the "*.lib" extension and close the dialog with OK. The library is now listed in the library manager and you can use the objects in the library as user-defined objects.

7.5 Remove Library

With the 'Edit' 'Delete' command you can remove a library from a project and from the library manager.

8 Visualization

8.1 Visualization

Visualizations allow you to view your project variables. With the help of visualizations, you can draw geometrical elements offline which can then change e.g. their form or color online in response to specified values of variables. For example it is possible to display the increase in a variable value with a bar chart.

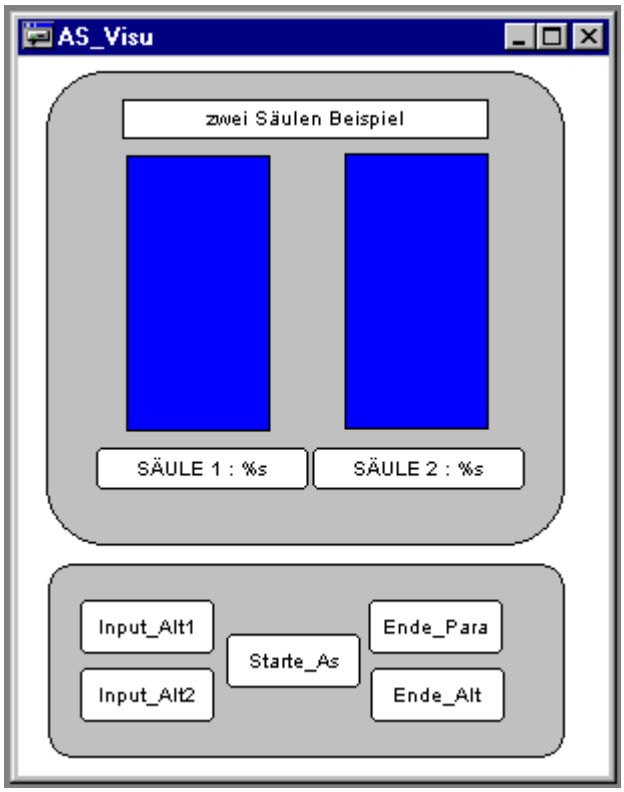
In Online mode, input to the program can then be carried out also via mouse and keyboard.

By using placeholders instead of concrete variables and text strings in configuring the visualization elements, a visualization object (visualization POU) can easily be used many time (referenced) by inserting it in other visualization objects and providing it there with various configuration (for example for visualizing different instances of a function block).

If a visualization object is to be inserted in another visualization, it is named 'Reference' and behaves in Online mode just like the original visualization, that is the corresponding elements of a reference from VisuA react simultaneously and identically to those from VisuA.

When a suitable translation file (see 'Project' 'Translate into other language') is available, visualization texts can be switched to another national language in Online mode.

X Example of a Visualization



8.2 Create Visualization

In order to create a visualization, you must select the register card for **Visualization** in the Object OrganizerUsing the **'Project' 'Object Add'** command, you can create a new visualization object. Open the 'New visualization' dialog, in which you can enter the name of the new visualization. Once a valid entry is made, that is not a name that is already in use and no special characters used, you can close the dialog with **OK**. A window opens, in which you can edit the new visualization.

8.2.1 Visualization Elements, Insert

8.2.1.1 Visualization Elements, Insert

You can insert four different geometric forms, as well as bitmaps, buttons and existing visualizations, into your visualization.

Geometric forms at your disposal *include:* rectangles, rounded rectangles, ellipses/circles, and polygons.

Go to the 'Insert' menu item and select freely from the following commands: 'Rectangle', 'Rounded Rectangle', 'Ellipse', 'Polygon', 'Line', 'Curve', 'Bitmap', 'Visualization' 'Button'. A check appears in front of the selected command. You can also use the tool bar. The selected element appears pushed down).

If you now go to the editor window with the mouse, you will see that the mouse pointer is identified with the corresponding symbol. Click on the

desired starting point of your element and move the pointer with pressed left mouse key until the element has the desired dimensions.

If you want to create a polygon or a line, first click with the mouse on the position of the first corner of the polygon resp. on the starting point of the line, and then click on the further desired corner points. By doubleclicking on the last corner point you will close the polygon and it will be completely drawn respectively the line will be completed. If you want to create a curve (Bezier curves) determine the initial and two other points with mouse clicks to define the circumscribing rectangle. An arc is drawn after the third mouse click. You can then change the position of the end point of the arc by moving the mouse and can then end the process with a double click or add another arc with additional mouse clicks.

Furthermore pay attention, to the status bar and the change from select and insert modes.

8.2.1.2 'Insert' 'Rectangle'

With the command you can insert a rectangle as an element into your present visualization. (Use, see Visualization Elements, Insert)

8.2.1.3 'Insert' 'Rounded Rectangle'

With the command you can insert a rectangle with rounded corners as an element in your present visualization. (Use, see Visualization Elements, Insert).

8.2.1.4 'Insert' 'Ellipse'

With the command you can insert a circle or an ellipse as an element in your present visualization. (Use, see Visualization Elements, Insert).

8.2.1.5 'Insert' 'Polygon'

With the command you can insert a polygon as an element in your present visualization. (Use, see Visualization Elements, Insert).

8.2.1.6 'Insert' 'Line'

With the command you can insert a line as an element into your current visualization. (Use, see Visualization Elements, Insert).

8.2.1.7 'Insert' 'Curve'

With the command you can insert a Bezier curve as an element into your current visualization. (Use, see Visualization Elements, Insert).

8.2.1.8 'Insert' 'Bitmap'

With the command you can insert a bitmap as an element in your present visualization. (Use, see Visualization Elements, Insert).

While pressing the left mouse button, bring up an area in the desired size. The dialog box is opened for opening a file. Once you have selected the desired bitmap, it will be inserted into the area brought up.

8.2.1.9 'Insert' 'Visualization'

With the command you can insert an existing visualization as an element in your present visualization. (Use, see Visualization Elements, Insert).

While pressing the left mouse button, bring up an area in the desired size. A selection list of existing visualizations opens. After you have selected the desired visualization, it will be inserted in the defined area.

An inserted visualization will also be named as a reference.

8.2.1.10 'Insert' 'Button'

This command is used to insert a button into your current visualization. (Use, see Visualization Elements, Insert).

Drag the element to the desired size with the left mouse button held down.

If a toggle variable is configured for the button it displays the state of this variable by visually displaying whether it is pressed or not pressed. Conversely, the variable is toggled by "pressing" the button.

8.2.2 Working with Visualization Elements

8.2.2.1 Selecting Visualization Elements

In order to select an element, click with the mouse on the element. You can also select the first element of the elements list by pressing the <Tab> key and jump to the next by each further keystroke. If you press the <Tab> key while pressing the <Shift> key, you jump backwards in the order of the elements list.In order to mark multiple elements, press and hold the <Shift> key and click the corresponding elements, one after another; or, while holding down the left mouse button, pull a window over the elements to be selected.

In order to select all the elements, use the 'Extras' 'Select All' command.

If you are in the element list (called by **'Extras' 'Element list'**), you can select the concerned element in the visualization by selecting a line.

8.2.2.2 Modifying Visualization Elements

You can select an element which has already been inserted by a mouse click on the element or by pressing the <tab> key. A small black square will appear at each corner of each of the elements, (with ellipses at the corners of the surrounding rectangle). Except in the case of polygons, lines or curves further squares appear in the middle of the element edges between the corner points.

With a selected element, the turning point (balance point) is also displayed at the same time. You can then rotate the element around this point with a set motion/angle. The turning point is displayed as a small black circle with a white cross ( ). You can drag the turning point with a pressed left mouse button.

You can change the size of the element by clicking on one of the black squares and, while keeping the left mouse button pressed, controlling the new outline.

With the selection of a *polygon*, you can drag each individual corner using the same technique. While doing this, if you press the <Ctrl>-key then an additional corner point will be inserted at the corner point, an additional corner point will be inserted, which can be dragged by moving the mouse. By pressing the <Shift>+<Ctrl>-key, you can remove a corner point.

8.2.2.3 Dragging Visualization Elements

One or more selected elements can be dragged by pressing the left mouse button or the arrow key.

8.2.2.4 Copying Visual Elements

One or more selected elements can be inserted with the **'Edit' 'Copy'**command, the **<Ctrl>+<C>** key combination, or the corresponding copy symbol, and with **'Edit' 'Paste'**.

A further possibility is to select the elements and to again click in one of these elements with the **<Ctrl>** key held down. If you now hold the left mouse button down, you can separate the elements thus copied from the original.

8.2.2.5 Changing the Selection and Insert Mode

After the insertion of a visualization element, there is an automatic change back into the selection mode. If you want to insert an additional element the same way, you can once again select the corresponding command in the menu or the symbol in the tool bar.

You can also quickly change between the selection mode and the insert mode by pressing the <Ctrl>-key and the right mouse button simultaneously.

In the insert mode, the corresponding symbol will also appear at the mouse pointer, and the name will also be indicated in black in the status bar.

8.2.2.6 Status Bar in the Visualization

If a visualization has the focus, the current **X** and **Y position** of the mouse cursor in pixels relative to the upper left corner of the image is displayed in the status bar. If the mouse pointer is located on an **Element**, or if the element is being processed, then the number of the element will be displayed. If you have selected an element to insert, then this element will also appear (for example, **Rectangle**).

8.2.3 Visualization Elements, Configure

8.2.3.1 'Extras' 'Configure'

With this command, the 'Configure element' dialog opens for configuring the selected visualization element (see Select visualization element). You are given the dialog box when you doubleclick on the element.

Select a category in the left area of the dialog box, and fill out the requested information in the right area.

Depending on the visualization element selected, various categories can be selected:

Shape	Rectangle, Rounded Rectangle, Ellipse
Text	All
Color	Rectangle, Rounded Rectangle, Ellipse, Polygon, Line, Curve
Motion absolute	All
Motion relative	All, except Polygon, Line, Curve
Variables	All
Input	All
Tooltip	All
Bitmap	Bitmap, Button
Visualization	Visualization

At locations in the element configuration where program variables are operative, the following **Entries** are possible:

- Variable names, for which input assistant is available
- Expressions which are assembled from component accesses, field accesses with constant index, variables and direct addresses.
- Operators and constants, which can be combined at will with the aforementioned expressions.

Examples of permissible expressions:

```
x + y

100*PLC_PRG.a

TRUE

NOT PLC_PRG.b

9*sin(x + 100)+cos(y+100)
```

Function calls are not possible. Invalid expressions result in an error message on login ("Invalid Watch expression..."). Examples of invalid expressions: fun(88), a := 9, RETURN.

There are two possible ways to write **global variables**: ".globvar" and "globvar" are equivalent. The style with a dot is not possible within an assembled expression, however.

See also below for the possible use of Placeholders.

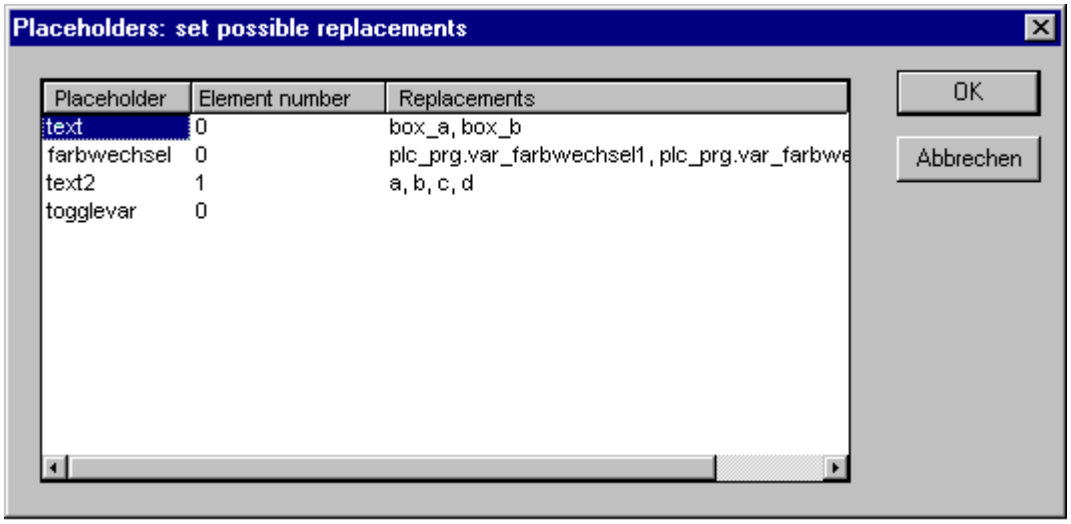
8.2.3.2 Placeholder

At each location in the configuration dialog at which variables or text are entered, a **placeholder** can be set in place of the respective variable or text. This makes sense if the visualization object is not to be used directly in the program, but is created to be inserted in other visualization objects as a reference. When configuring such a **Reference**, the placeholders can be replaced with variable names or with text (see "Configuring an inserted visualization"). Any text enclosed in two dollar signs ($) is a valid placeholder (e.g. $variable1$, variable$x$). For each placeholder, a "value group" can be defined as an input specification in the 'Placeholder list' dialog (called from 'Extras' 'Placeholder list').

8.2.3.3 'Extras' 'Placeholder list'

This dialog applies to the visualization object that has the input focus. It displays the placeholders set in that object and allows prior definition of what values each placeholder can be replaced with when configuring a reference of this visualization (see 'Visualization').

X Placeholder list for input of possible replacements for the placeholders

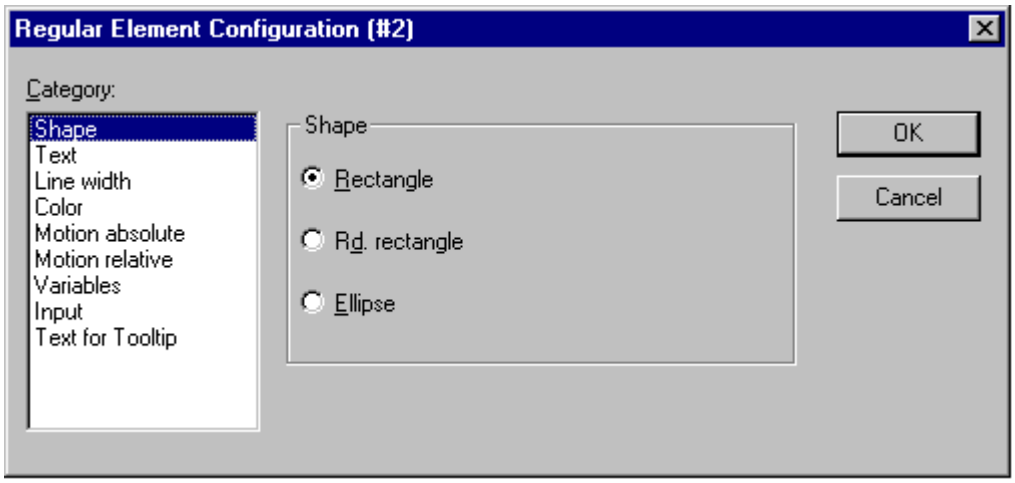


All placeholders provided for in the visualization are listed in the **Placeholder** column. The Element number column shows in which element a placeholder has been configured. A selection of strings, which can then be used as input in a reference in place of the placeholder, can be entered for these placeholders in the **Replacements** column. The elements of the selection must be entered separated by commas. If an impossible replacement string is specified, then the placeholder can be replaced with any desired text when configuring the reference that contains it.

8.2.3.4 Shape

In the visualization element configuration dialog box, you can select in the **Shape** category from among **Rectangle**, **Rounded Rectangle**, and **Ellipse** respectively **Polygon, Line** and **Curve**. The form will change into the size already set.

X Dialog Box for Configuring Visualization Elements (Shape Category)



8.2.3.5 Text

In the dialog for configuring visualization elements, you can specify a text for the element in the **Text** category, which can be entered directly or represented by a placeholder.

Enter the text in the **Content** field. With the key combination <Crtl>+<Enter> you can insert line breaks, with **<Crtl>+<Tab>**, tab stops.

If you enter "<name>" into the text, then this location, in Online mode, will be replaced by the value of the variable from the **Text Output** field of the **Variables** category.

Note:
If a text string is to be transferred into a **translation file**, which will then be used in Online mode to enable switching into another national language, it must be delimited at the beginning and end by #.

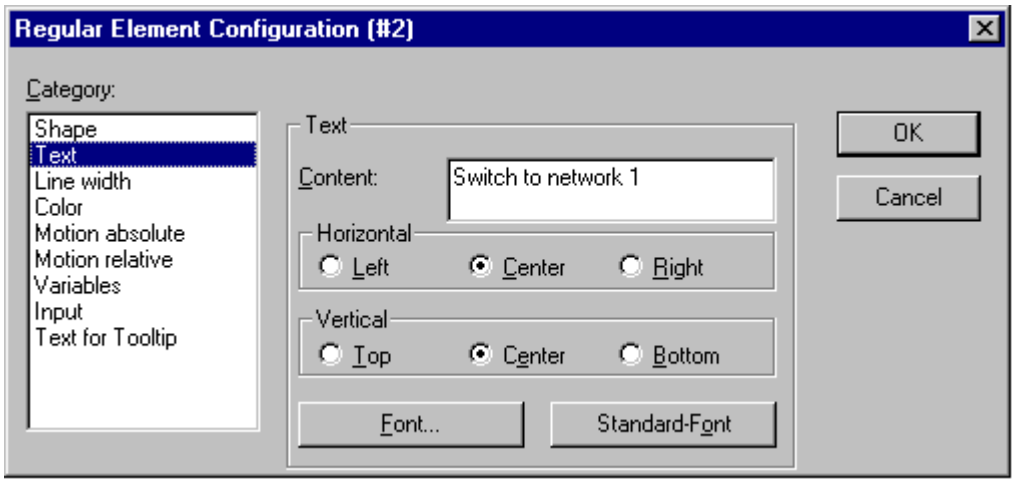
Examples: "#Pump 1#" or else even "#Pump# 1"

The second case might for example, in the event of multiple occurrences of the text Pump (Pump 1, Pump 2, etc.), prevent multiple appearances in the translation.

The configured text will appear online in the prescribed alignment within the element: **horizontally left**, **center** or **right** and **vertically top**, **center** or **bottom**.

If you use the **Font** button, a dialog box for selection of the font will appear. Select the desired font and confirm the dialog with **OK**. With the **Standard-Font** button you can set the font that is selected in the project options ('Project' 'Options' 'Editor'**).** If the font is changed there, then this font will be displayed in all elements except in those elements for which another font has explicitly been selected by using the **Font** button.

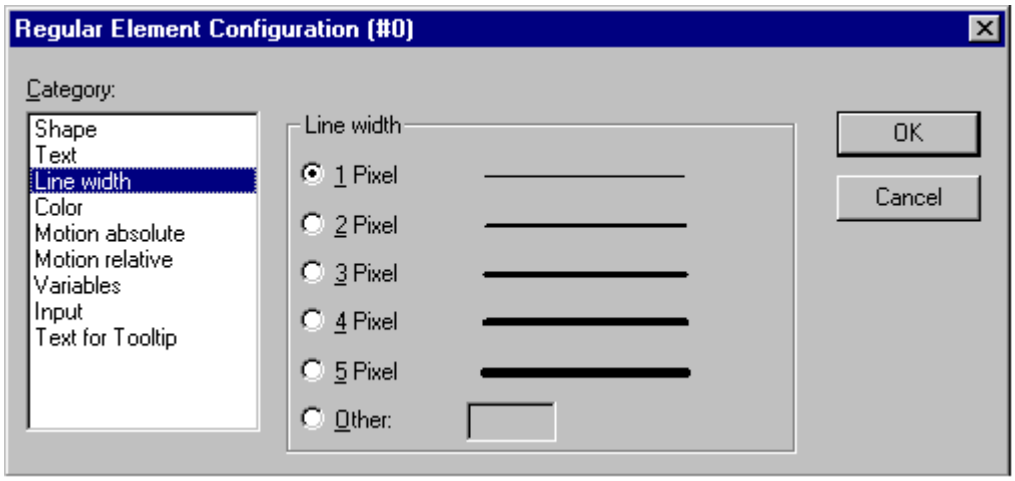
X Dialog Box for Configuring Visualization Elements (Text Category)



8.2.3.6 Line width

In the dialog for configuring visualization elements, you can choose the line width for an element. As predefined options you find width settings from 1 to 5 pixel, additionally an other value can be entered manually.

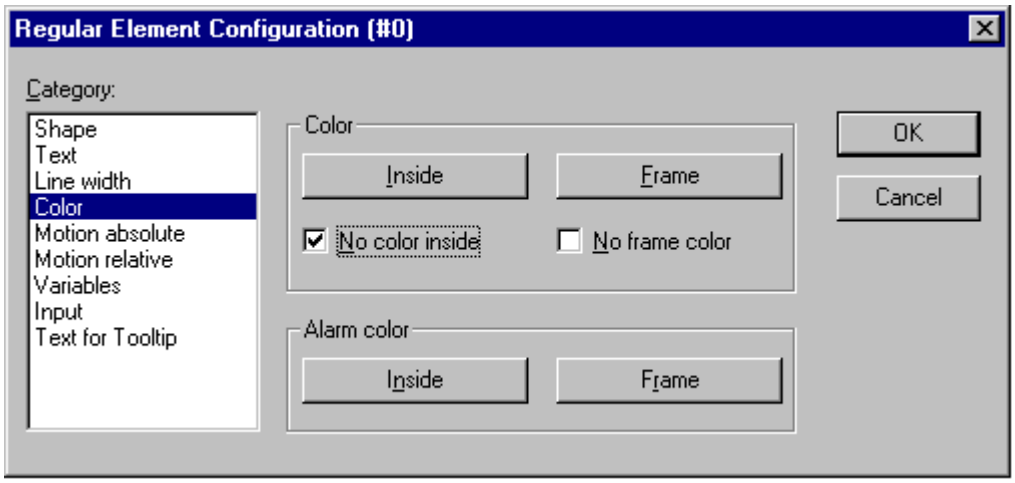
X Dialog Box for Configuring Visualization Elements (Line width category)



8.2.3.7 Colors

In the visualization element configuration dialog box, in the **Color** category you can select primary colors and alarm colors for the inside area and for the frame of your element. Chosing the options **no color inside** and **no frame color** you can create transparent elements.

X Dialog Box for Configuring Visualization Elements (Color Category)



If you now enter a Boolean variable in the **Variables** category in the **Change Color** field, then the element will be displayed in the **Color** set, as long as the variable is FALSE. If the variable is TRUE, then the element will be displayed in its **Alarm Color**.

Note:
The change color function only becomes active, if the PLC is in *Online Mode*!

If you want to change the color of the frame, then press the **Frame** button, instead of the **Inside** button. In either case, the dialog box will open for selection of the color.

Here can to choose the desired hue from the primary colors and the user-defined colors. By pressing the Define Colors you can change the user-defined colors.

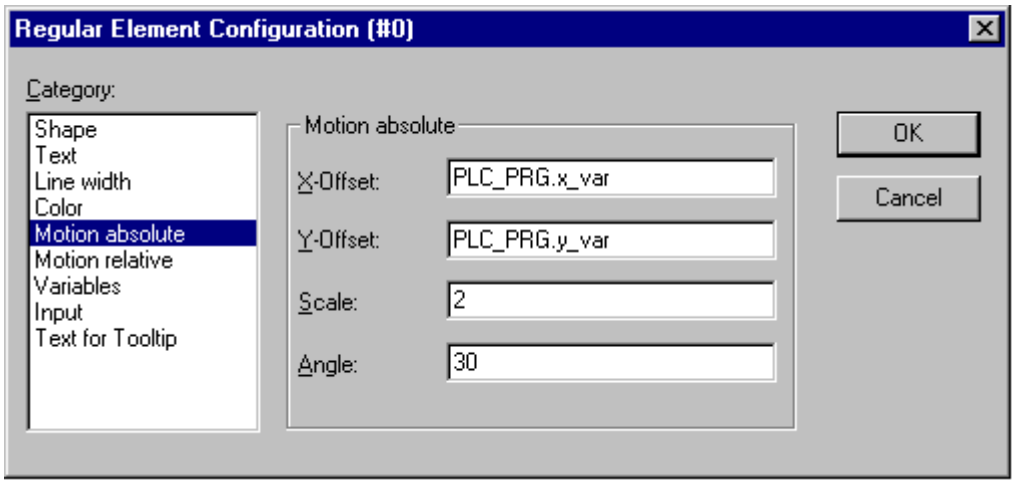
8.2.3.8 Motion absolute

In the visualization element configuration dialog box, in the **Motion absolute** category, **X-** or **Y-Offset** fields variables can be entered. These variables can shift the element in the X or the Y direction, depending on the respective variable value. A variable in the **Scale** field changes the size of the element linear to the value of the variable.

A variable in the **Angle** field causes the element to turn on its turning point, depending on the value of the variable. (Positive Value = Mathematic Positive = Clockwise). The value is evaluated in degrees. With polygons, every point rotates; in other words, the polygon turns. With all other elements, the element rotates, in such a way, that the upper edge always remains on top.

The turning point appears after a single click on the element, and is displayed as a small black circle with a white cross (⊕). You can drag the turning point with a pressed left mouse button.

X Visualization Element Configuration Dialog Box (Motion Absolute Category)



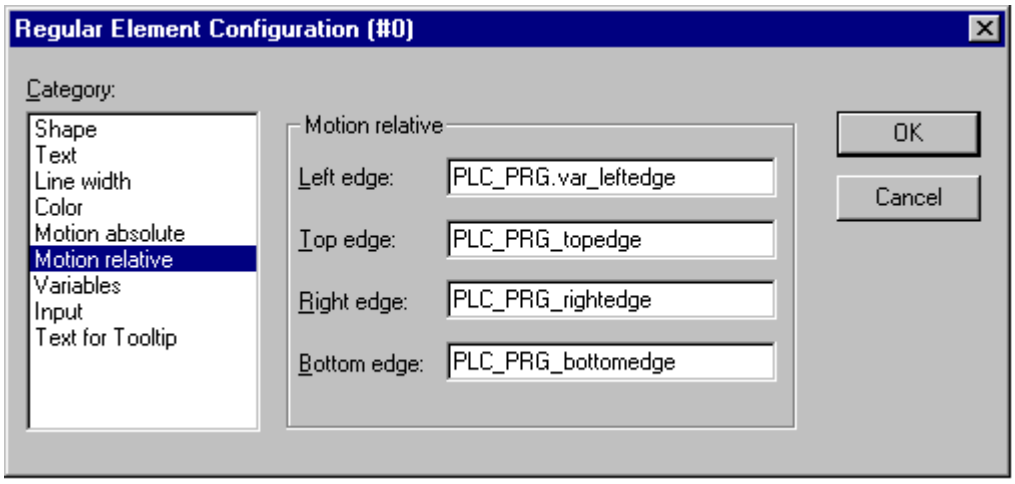
8.2.3.9 Motion relative

In the dialog for configuring visualization elements in the **Motion Relative** category, you can assign variables to the individual element edges. Depending on the values of the variables, the corresponding element edges are then moved. The easiest way to enter variables into the fields is to use the Input Assistant (<F2>).

The four entries indicate the four sides of your element. The base position of the corners is always at zero. A new value in the variables, in the corresponding column, shifts the boundary in pixels around this value. Therefore, the variables that are entered ought to be INT variables.

Note:
Positive values shift the horizontal edges downward, or, the vertical edges, to the right!

X Dialog Box for Configuration of Visualization Elements (Motion Relative Category)



8.2.3.10 Variables

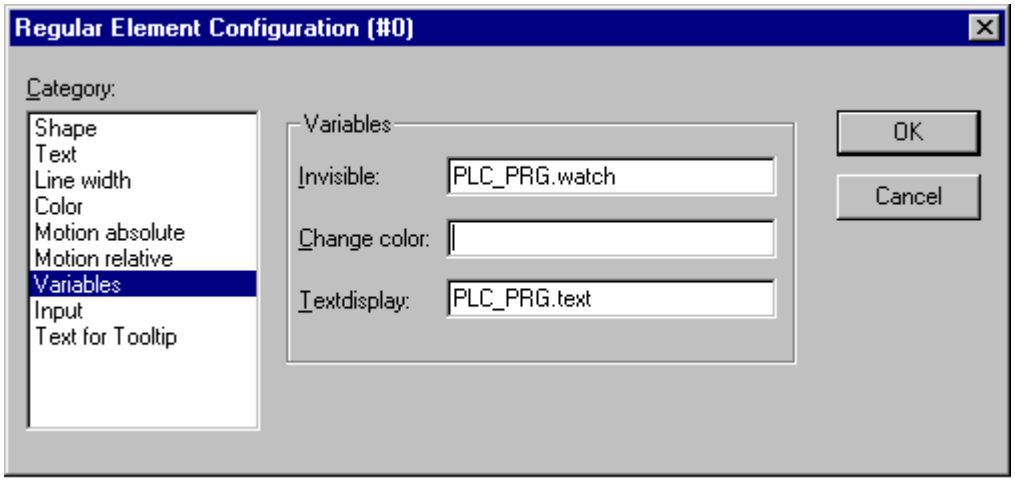
You can enter the variables that describe the status of the visualization elements in the **Variable** category within the dialog box for configuring visualization elements. The simplest way to enter variables in the fields is to use the Input Assistant.

You can enter Boolean variables in the **Invisible** and **Change color** fields. The values in the fields determine their actions. If the variable of the **Invisible** field contains the value FALSE, the visualization element will be visible. If the variable contains the value TRUE, the element will be invisible.

If the variable at the **Change color** field contains the value FALSE, the visualization element will be displayed in its default color. If the variable is TRUE, the element will be displayed in its alarm color.

In the **Textdisplay** field, you can specify a variable whose value is displayed in the visualization, as long as you have entered "<name>" in addition to the text in the **Content** field of the **Text** category. The "<name>" is replaced in Online mode by the value of the variable from the Textdisplay field. If you want to edit the value of the variable in Online mode using the keyboard, you can do this via the 'Text input of variable' 'Textdisplay' in the Input category.

X Visualization Element Configuration Dialog Box (Variables Category)



8.2.3.11 Input

Selecting the field **Toggle variable** allows you, in online mode, to toggle the value of the variables which are located in the input field with every mouse click on the element. You can obtain input assistance for data entry via **<F2>**. The value of the Boolean variable changes with each mouse click from TRUE to FALSE and then back to TRUE again at the next mouse click, etc.

You can also use input assistance for entry of a variable for the Tip Variable option. This option allows you, in online mode, to change the value of the Boolean variable which is located in the input field, between TRUE and FALSE. Place the mouse cursor on the element, press the mousekey and hold it depressed. If option Tip FALSE is activated, the value is set to FALSE as soon as the mouse key is pressed, otherwise it is set to TRUE at this moment. The variable changes back to its initial value as soon as you release the mouse key.

Selecting the field Zoom to Vis... allows you to enter the name of a visualization object of the same project into the edit field. You can then switch to the window showing this visualization in Online mode by clicking on the element with the mouse. The window of the target visualization will first open, followed by the closing of that of the current one. While in online mode use a mouse click to change to the element in the window of the visualization which has been entered. If a program variable of the type STRING (e.g. PLC_PRG.xxx) has been entered instead of a visualization object, then this variable can be used to define the name of the visualization object (e.g.

,visu1') which the system should change to when a mouse click occurs (e.g. xxx:= ,visu1).

If a visualization reference that contains placeholders is to be jumped to, these can be directly replaced by variable names or text when called up. For this purpose, conform to the following syntax:

```
<Visuname>(<Placeholder1>:=<Text1>,
      <Placeholder2>:=<Text2>,..., <Placeholder
      n>:=<Textn>)
```

Example:

Calling the visualization visu1, whereby the placeholders var_ref1 and var_ref2 used in visu1 are replaced by the variables PLC_PRG.var1 and PROG.var1 respectively:

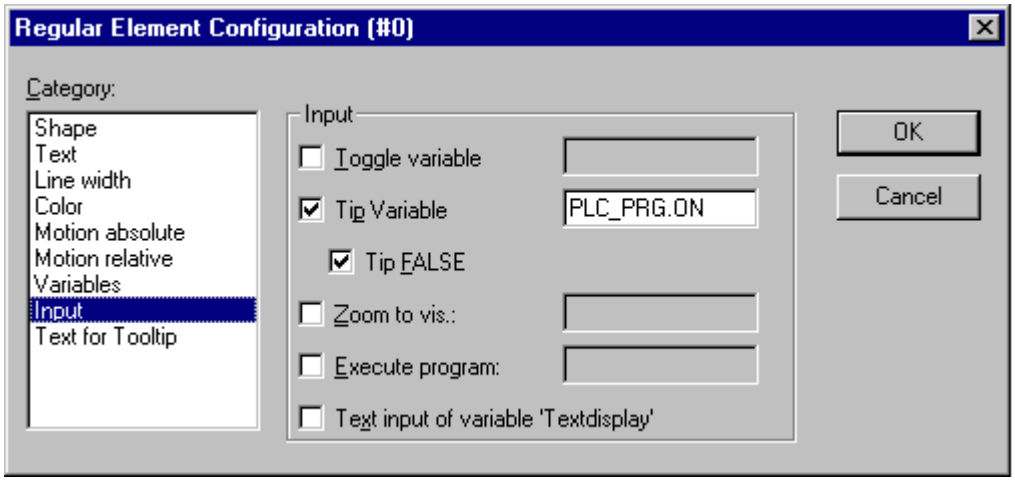
```
visu1(var_ref1:=PLC_PRG.var1, var_ref2:=PROG.var1)
```

If you issue the command "ZOOMTOCALLER" in the Zoom to vis. field, a backward jump into the calling visualization is achieved in Online mode by a mouse click on the element, if such a constellation was configured.

Selecting the option Execute program allows you to enter any executable program in the input field and then to execute it in online mode by clicking on the element with the mouse. Example: notepad C:/help.txt (the Notepad program is started and the help.txt file is opened).

If you select the Text input of variable 'Textdisplay' in Online mode, you get an editing space in this visualization element. You can enter a value in this which will upon pressing <Enter> be written to the variable that appears in the Textdisplay field of the Variables category.

X Dialog to configure the visualization elements (Category Input)



8.2.3.12 ToolTip

The dialog Text for Tooltip offers an input field for text which appears in a text field as soon as the mouse cursor is passed over the object in online mode. The text can be formatted with line breaks by using the key combination <Ctrl> + <Enter>.

8.2.3.13 Bitmap

You can enter the options for a bitmap in the **Bitmap** category within the visualization element configuration dialog box.

Enter the bitmap file and its path in the Bitmap field. You can use the ... button to open the standard Windows Browse dialog box from which you can select the desired bitmap.

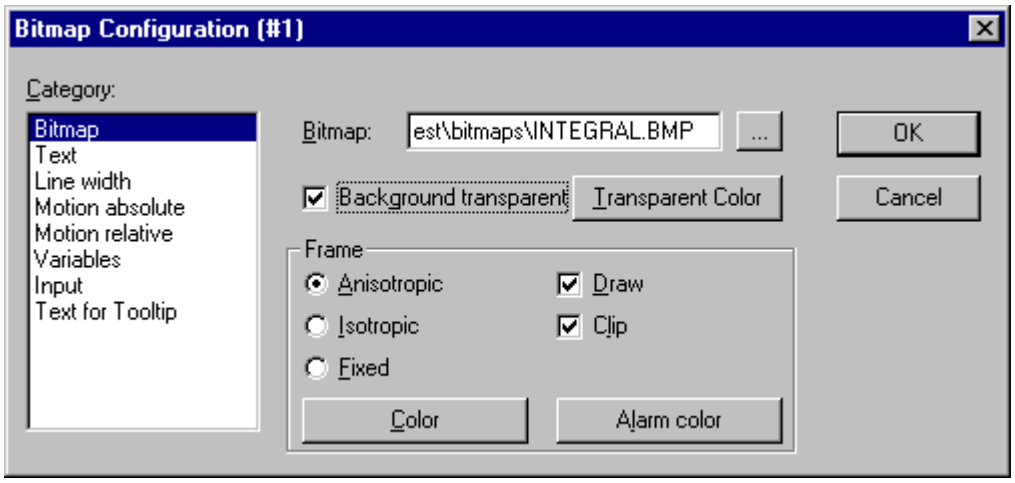
All other entries affect the frame of the bitmap.

By selecting Anisotropic, Isotropic or Fixed you specify how the bitmap should react to changes in the size of the frame. Anisotropic means that the bitmap remains the same size as the frame which allows you to change the height and width of the bitmap independently. Isotropic means that the bitmap retains the same proportions even if the overall size is changed (i.e., the relationship between height and width is maintained). If Fixed is selected, the original size of the bitmap will be maintained regardless of the size of the frame.

If the Clip option is selected together with the Fixed setting, only that portion of the bitmap that is contained within the frame will be displayed.

If you select the Draw option, the frame will be displayed in the color selected in the Color and Alarm color buttons in the color dialog boxes. The alarm color will only be used if the variable in the Change Color field in the Variable category is TRUE.

X Visualization Element Configuration Dialog Box (Bitmap Category)



8.2.3.14 Visualization

You can enter the options for a visualization as an element in another visualization in the **Visualization** category within the visualization element configuration dialog box. Enter the object name for the visualization in the **Visualization** field. Use the **...** button to open a dialog box containing the visualizations available in this project. Any visualization may be used with the exception of the current one.

All other entries affect the visualization **frame**.

If you select the **Draw** option, the frame will be displayed in the color selected in the **Color** and **Alarm color** buttons in the color dialog boxes. The alarm color will only be used if the variable in the **Change Color** field in the **Variables** category is TRUE.

If **Isotropic** is selected, the proportions of the visualization will be maintained even if the size changes (i.e., the relationship between height and width will remain the same). Otherwise the proportions can be changed.

If the **Clip** option is selected in Online mode, only the original portion of the visualization will be displayed. For example, if an object extends beyond the original display area, it will be clipped and may disappear from view completely in the visualization.

The **Placeholder** button leads to the 'Replace placeholder' dialog. It lists in the 'Placeholder' column all the placeholders used in the inserted visualization POU and offers in the 'Replacements' column the possibility of replacing these with a definite value. Which replacements are possible in a given case depends on whether a value group was predefined in the 'Extras' 'Placeholder list' dialog. If this is the case, it will be displayed in a combo box for selection. If nothing was pre-defined, double clicking on the corresponding field in the Replacements column opens an editing field which can be filled in as desired.

A further possibility for replacing placeholders in references occurs directly during the calling of a visualization, by entry into the **Zoom to vis.** option field in the 'Input' category of the configuration dialog for a visualization element.

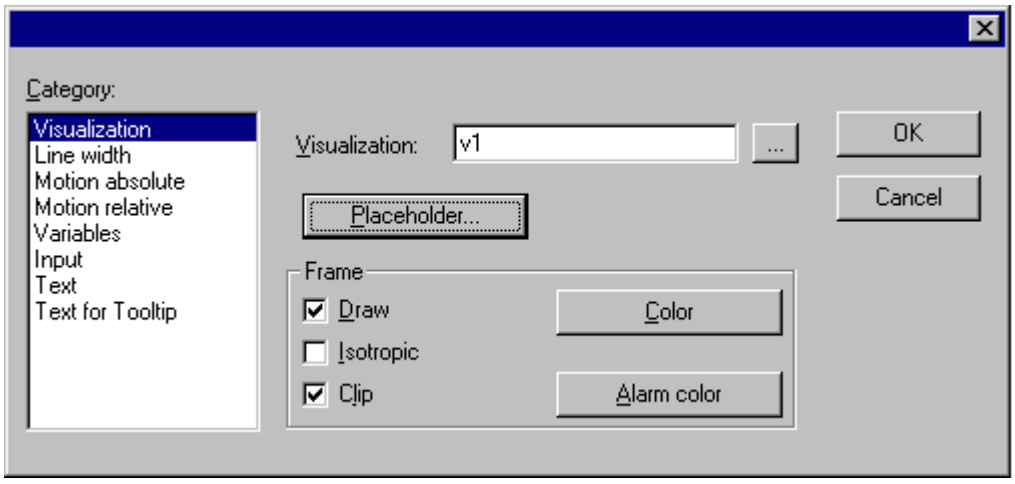
Note:
No control of the chronological sequence of replacements is possible! Therefore no placeholders should be replaced with text that also contains placeholders!

Note:
When using placeholders it is no longer possible to check for invalid entries in the configuration of the visualization element immediately upon compilation of the project. Hence the appropriate error messages are first issued in Online mode (...Invalid Watch expression..).

Example of an application of the placeholder concept:

Instances of a function block can easily be displayed with the help of references of the same visualization. For example, in configuring the visualization visu, which visualizes the variables of function block fu, one could begin each variable entry with the placeholder FUB (e.g. FUB.a). If a reference from visu is then used (by inserting visu in another visualization or by calling via 'Zoom to vis.'), then in the configuration of this reference the placeholder FUB can then be replaced with the name of the function block fu instance to be visualized (for example FUB -> PLC_PRG.inst_1). In another reference of visu, FUB could be replaced with another instance of fu.

X Visualization Element Configuration Dialog Box (Visualization Category)



8.2.4 Additional Visualization Element Functions

8.2.4.1 'Extras' 'Send to Front'

Use this command to bring selected visualization elements to the front.

8.2.4.2 'Extras' 'Send to Back'

Use this command to send selected visualization elements to the back.

8.2.4.3 'Extras' 'Select Background Bitmap'

Use this command to open the dialog box for selecting files. Select a file with the extension "*.bmp". The selected bitmap will then appear as the background in your visualization.

The bitmap can be removed with the command 'Extras' 'Clear Background Bitmap'.

8.2.4.4 'Extras' 'Clear Background Bitmap'

Use this command to remove the bitmap as the background for the current visualization.

You can use the command 'Extras' 'Select Background Bitmap' to select a bitmap for the current visualization.

8.2.4.5 'Extras' 'Align'

Use this command to align selected visualization elements.

The following alignment options are available:

- **Left**: the left edge of each of the elements will be aligned to the element that is furthest to the left
- the same is true for **Right** / **Top** / **Bottom**
- **Horizontal Center**: each of the elements will be aligned to the average horizontal center of all elements
- **Vertical Center**: each of the elements will be aligned to the average vertical center of all elements

8.2.4.6 'Extras' 'Select All'

This command allows you to select all visualization elements within the current visualization object.

8.2.4.7 'Extras' 'Select Mode'

This command is used to switch the selection mode on or off. This can also be achieved using the symbol or by pressing the right mousekey while holding down the <**Ctrl**> key at the same time.

8.2.4.8 'Extras' 'Element list'

This command opens a dialog box containing a list of all visualization elements including their **number, type** and **position**. The position is given according to the x and y position of the upper left and lower right corner of the element.

When one or more items have been selected, the corresponding elements in the visualization are marked for visual control and if necessary the display will scroll to that section of the visualization that contains the elements.

Use the **To front** button to bring selected visualization elements to the front. Use the **To behind** button to move them to the back.

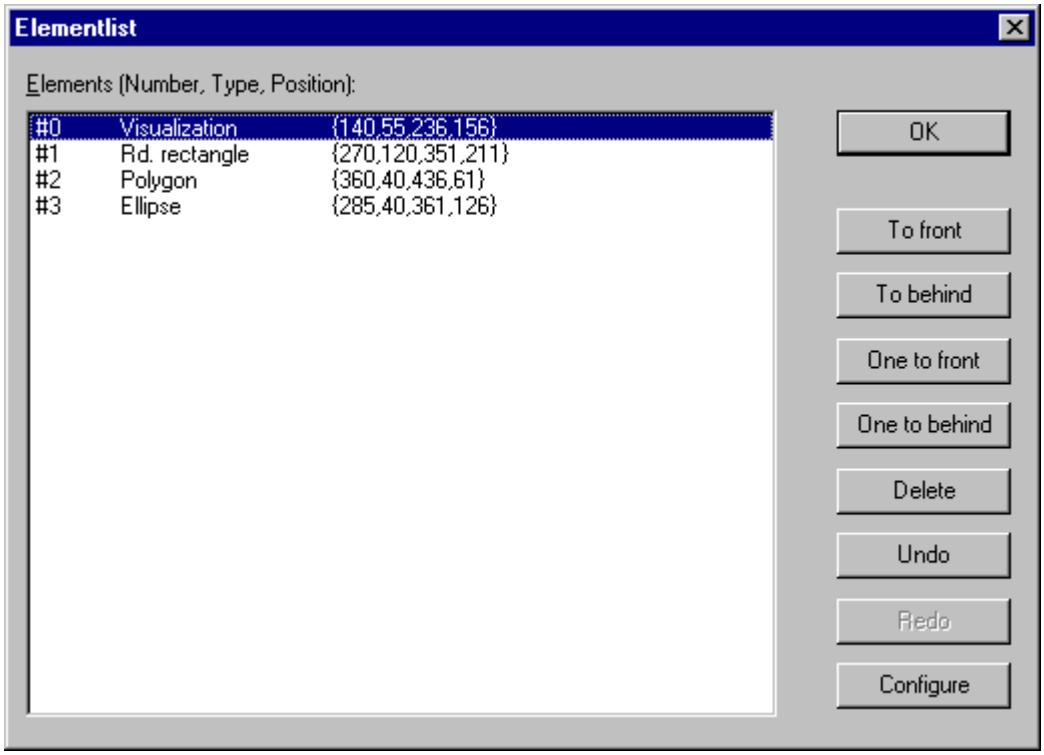
Use the **Delete** button to remove selected visualization elements.

Use the Undo and Redo buttons to undo or restore changes that have been made just as you would do with the commands 'Edit' 'Undo' and 'Edit' 'Redo' . In the dialog box, you can observe the changes that are being made.

Click on **OK** to close the dialog box and confirm the changes.

Use **Configure** to get the configuration dialog for the element.

x Element list dialog box



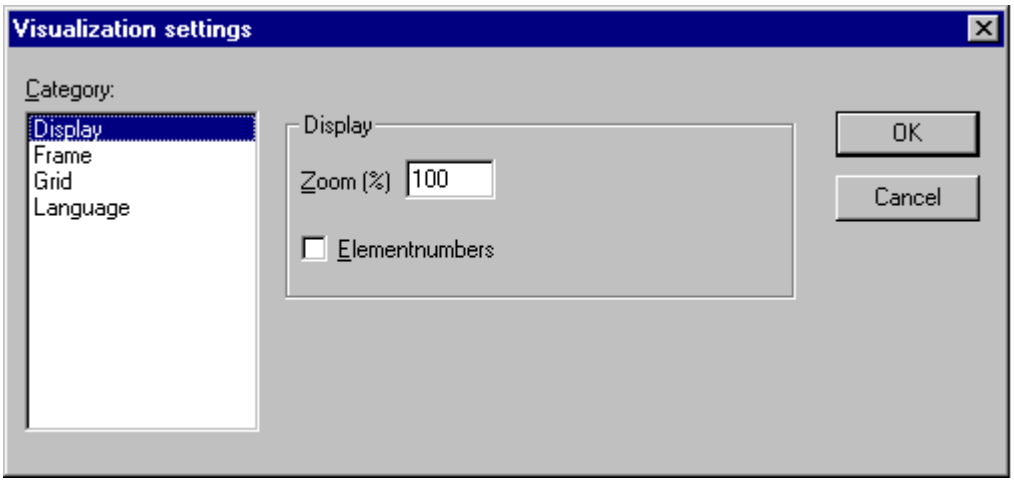
8.2.4.9 'Extras' 'Settings'

When this command is used, a dialog box will open in which you can make certain settings that affect the visualization.

Note:
The categories **Display, Frame** and **Language** also can be edited in the online mode.

- Category **Display** : Enter a zoom factor into the field **Zoom** of between 10 and 500 % in order to increase or decrease the size of the visualization display.

  x Setting dialog for visualizations (Category Display)



- Category **Frame**: If **Auto-scrolling** is selected, the visible portion of the visualization window will move automatically when you reach the edge while drawing or moving a visualization element. If **Best fit in Online mode** is selected, the entire visualization including all elements will be shown in the window in Online mode regardless of the size of the window. When **Include Background Bitmap** is selected, the background bitmap will be fitted into the window as well, otherwise only the elements will be considered.
- Category **Grid:** Define here whether the grid points are **visible** in the offline mode, whereby the spacing between the visible points is at least 10 even if the entered size is smaller than that. In this case the grid points only appear with a spacing which is a multiple of the entered size. Selecting **Active** causes the elements to be placed on the snap grid points when they are drawn and moved. The spacing of the grid points is set in the field **Size**.
- Category **Language** : Here you can specify in which national language the text that you assigned to an element in the **Text** and **Text for Tooltip** options should be displayed.

  For this, there must either be a *.tlt translation file for the project, or a *.vis language file created especially for the visualization.

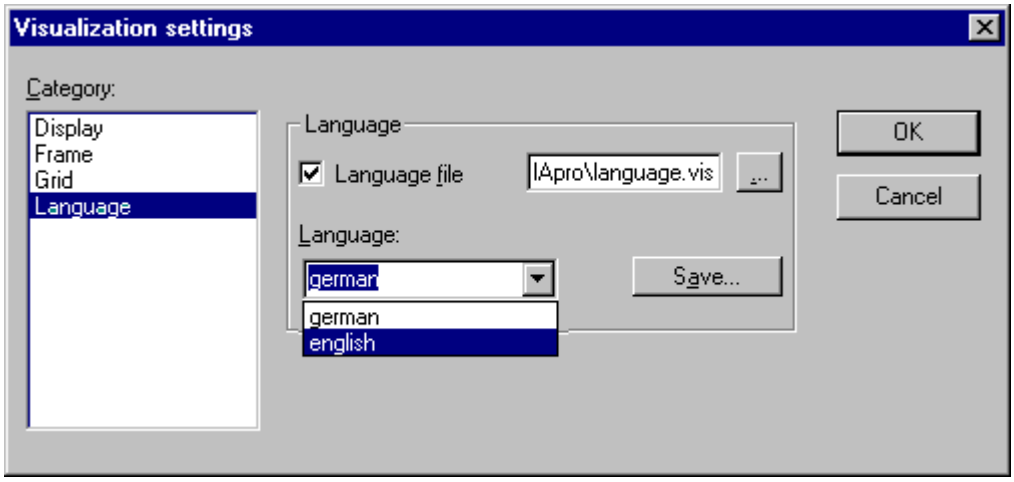
Note:
The text display changes only in Online mode!

Regarding creating a translation file, please see 'Project' 'Translate into other languages'.Project..Translateintoanotherlanguage.>Proc.
For creating a special *.vis **language file** for the visualization, see below. This option is retained for reasons of compatibility with projects created under Version 2.1.

In order to select a translation or language file, activate the **Language file** option in the dialog and enter in the input field next to it the appropriate file path, or obtain the help of the standard file opening dialog via the button.

In the selection window under **Language** you can now select among the options *German* and *English* in the example shown here.

X Selection of a language file for a visualization



Creating a *.vis language file:

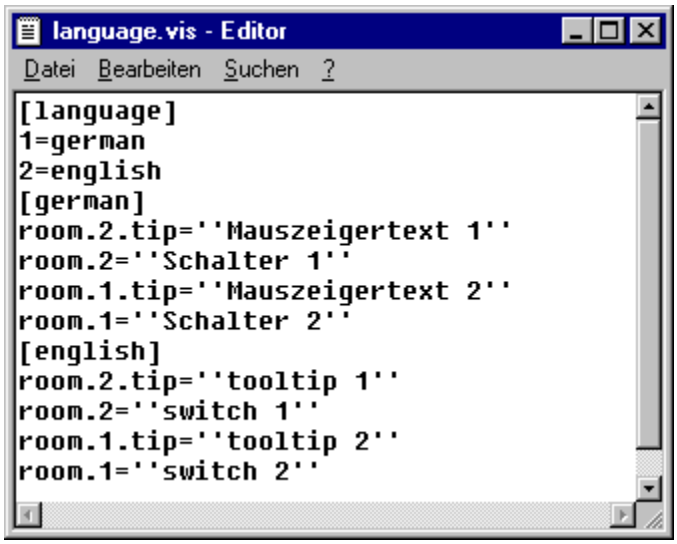
In order to set up a new *.vis language file for the visualization, proceed as follows:

Open likewise the **Settings** Visualization dialog, **Language** category.

Choose option language file. In the associate input field enter where you want to store the file. The extension is **.vis**. You also can use the dialog 'Open file' by pressing the button . If a language file with the extension .vis is already present, it will be offered to you here.

In the input field next to **Language** you fill in a keyword for the language which is currently used in the visualization, i.e."german" (or "D"). then press the button **Save**. A file with the extension .vis will be created, which now can be edited by a normal text editor. For example you can open the file by NOTEPAD:

X Example of a language file for a visualisation (Category Language)



You get a list of the text variables for the language currently used in the visualization. It includes a reference to the title of this list, for example "1=german" as reference to the title [german]. You can extend the list by copying all lines, then replacing the German by English text and setting a new title [english]. Beyond the line 1=german you accordingly have to add 2=english.

To view the visualization in one of the prepared languages, open the dialog **Language** again. In the option field beyond **Language** now you can choose between *german* and *english* (for the example described above).

Note:
The text display does not change before switching to Online Mode !

Calling up language-dependent Online Help via a visualization element:

The calling of a different Help file with a visualization element can be tied in with the language currently entered for the visualization. For this purpose, the command INTERN HELP must be entered for this element in the 'Configure element' dialog at the location 'Execute program', and a [Visu-Helpfiles] section must be present in the **WAGO-I/O-*PRO* 32** .ini file. Below this, the corresponding help files must be assigned to the languages available for selection in the visualization: e.g.:

```
[Visu-Helpfiles]

German=C:\PROGRAMME\HELP_D.HLP

English=C:\PROGRAMME\HELP_E.HLP
```

8.2.4.10 Operation over the keyboard - in online mode

The visualization elements can be manipulated in online mode over the following key functions:

Pressing the **<Tabulator>** key selects the first element in the element list for which an input is configured. Each subsequent pressing of the key moves one to the next element in the list. Pressing the key while keeping the <Shift> key depressed selects the previous element.

The arrow keys can be used to change from a selected element to a neighbouring one in any direction.

The <**Space bar**> is used to execute an activity on the selected visualization element. If the element is one which has a text output variable, a text input field will be opened which displays the text contents of the variable. Pressing the <**Enter**> key writes in this value.

The individual elements of references behave in Online mode identically to the corresponding ones in the visualization that is referenced. They will therefore react the same way as individual elements to inputs and operation by mouse and keyboard; the display of tooltips in references is also element-dependent. When processing the element list, as for instance when jumping from one input element to the next using the tabulator, the processing of all individual elements of a reference proceeds from the location of the reference in the element list before jumping to the next element of the list.

Note:
Operation over the keyboard in online mode is of greatest significance for the operation version of **WAGO-I/O-*PRO* 32**!

8.2.4.11 'File' 'Print' in online mode

'File' 'Print'is used to print out the contents of the visualization window in online mode. Visualizations which stretch over the border of the window can lead to inconsistencies particularly when there are moving elements in the visualization.

8.2.4.12 Visualizations in libraries

Visualizations can also be stored in libraries and thus be made available to projects as library POUs. They can be inserted as references like the visualizations directly present in the project, or they can be called up via the command "Zoom to vis." in the input configuration of another visualization.

Note:
Visualizations used in a project must have unique names. It can be problematic if for instance a visualization from a library is called or referenced which has the same name as one present in the project. Because, in processing references or visualization calls in the program, first the visualizations in the project, and only thereafter the ones in the loaded libraries will be implemented.

9 DDE Interface

9.1 DDE Communication with WAGO-I/O-PRO 32

WAGO-I/O-*PRO* 32 has a DDE (dynamic data exchange) interface for reading data. **WAGO-I/O-*PRO* 32** uses this interface to provide other applications that also use a DDE Interface with the contents of control variables and IEC addresses

If the GatewayDDEServer is used, which works with symbols, **WAGO-I/O-*PRO* 32** is not needed to read variables values from the PLC and to transfer them to applications with an DDE interface.

Attention:
Direct addresses cannot be read over the DDE server ! For this case you have to define variables in **WAGO-I/O-*PRO* 32** which are assigned to the desired addresses (AT).

Attention:
The DDE interface has been tested with Word 97 and Excel 97 on Windows NT 4.0. If the DDE communication fails caused by a mismatch of other versions or additionally installed programs on a computer, WAGO Kontakttechnik GmbH cannot take any responsibility.

9.2 DDE interface of the WAGO-I/O-PRO 32 programming system

9.2.1 Activating the DDE Interface

The DDE interface becomes active as soon as the PLC (or the simulation) is logged in.

9.2.2 General Approach to Data

A DDE inquiry can be divided into three parts:

1. Name of the program (here: WAGO-I/O-PRO 32),
2. File name and
3. Variable name to be read.

Name of the program: **WAGO-I/O-*PRO* 32**

File name: complete project path (c:\example\example.pro).

Variable name: The name of a variable as it appears in the Watch and Receipt Manager .

9.2.3 Which variables can be read?

All addresses and variables are readable. Variables or addresses should be entered in the format used in the Watch and Receipt Manager

Examples:

%IX1.4 (* Reads the input 1.4*)

PLC_PRG.TEST (* Reads the variable TEST from the POU PLC_PRG*)

.GlobVar1 (* Reads the global variable GlobVar1 *)

9.2.4 Linking variables using WORD

In order to get the current value of the variable TEST from the POU PLC_PRG through the DDE interface in Microsoft WORD, a field (e.g., the date) must be inserted in WORD ('Insert' "Field"). Now when you click on the field with the right mouse button and select the command "Toggle Field Codes" you can change the field function for the chosen text. In our example, this would look as follows:

```
{ DDEAUTO WAGO-I/O-PRO 32 "C:\WAGO-I/O-PRO
     32\PROJECT\IFMBSP.PRO" "PLC_PRG.TEST" }
```

Click on the field with the right mouse button again, then click on "Update Field" and the desired variable content appears in the text.

9.2.5 Linking variables using EXCEL

The following must be entered in Microsoft EXCEL before you can assign a variable to a cell.

```
=WAGO-I/O-PRO 32|'C:\WAGO-I/O-PRO
     32\PROJECT\IFMBSP.PRO'!PLC_PRG.TEST'
```

When you click on 'Edit' then "Links", the result for this link will be:

Type: WAGO-I/O-PRO 32

Source file: C:\WAGO-I/O-PRO 32\PROJECT\IFMBSP.PRO

Element: PLC_PRG.TEST

9.2.6 Accessing variables with Intouch

Link with your project a DDE Access Name <AccessName> with the application name WAGO-I/O-PRO 32 and the DDE topic name C:\WAGO-I/O-PRO 32\PROJECT\IFMBSP.PRO.

Now you can associate DDE type variables with the access name <AccessName>. Enter the name of the variable as the Item Name (e.g., PLC_PRG.TEST).

10 Keyboard Commands

10.1 Use of Keyboard

If you would like to run **WAGO-I/O-*PRO* 32** using only the keyboard, you will find it necessary to use a few commands that are not found in the menu.

- The function key **<F6>** allows you to toggle back and forth within the open POU between the Declaration and the Instruction parts.
- **<Alt>** + **<F6>** allows you to move from an open object to the Object Organizer and from there to the Message window if it is open. If a Search box is open, **<Alt>** + **<F6>** allows you to switch from Object Organizer to the Search box and from the there back to the object.
- Press **<Tab>** to move through the input fields and buttons in the dialog boxes.
- The arrow keys allow you to move through the register cards and objects within the Object Organizer and Library Manager.

All other actions can be performed using the menu commands or with the shortcuts listed after the menu commands. **<Shift> + <F10>** opens the context menu which contains the commands most frequently used for the selected object or for the active editor.

10.2 Key Combinations

The following is an overview of all key combinations and function keys:

General Functions	
Move between the declaration part and the instruction part of a POU	**<F6>**
Move between the Object Organizer, the object and the message window	**<Alt>+<F6>**
Context Menu	**<Shift>+<F10>**
Shortcut mode for declarations	**<Ctrl>+<Enter>**
Move from a message in the Message window back to the original position in the editor	**<Enter>**
Open and close multi-layered variables	**<Enter>**
Open and close folders	**<Enter>**
Switch register cards in the Object Organizer and the Library Manager	**<Arrow keys>**
Move to the next field within a dialog box	**<Tab>**
Context sensitive Help	**<F1>**
General Commands	
'File' 'Save'	**<Ctrl>+<S>**

'File' 'Print'	**<Ctrl>+<P>**
'File' 'Exit'	**<Alt>+<F4>**
'Project' 'Check'	**<Strg>+<F11>**
'Project' 'Build'	**<Shift>+<F11>**
'Project' 'Rebuild all'	**<F11>**
'Project' 'Delete Object'	**<Del>**
'Project' 'Add Object'	**<Ins>**
'Project' 'Rename Object'	**<Spacebar>**
'Project' 'Open Object'	**<Enter>**
'Edit' 'Undo'	**<Ctrl>+<Z>**
'Edit' 'Redo'	**<Ctrl>+<Y>**
'Edit' 'Cut'	**<Ctrl>+<X> or <Shift>+<Del>**
'Edit' 'Copy'	**<Ctrl>+<C>**
'Edit' 'Paste'	**<Ctrl>+<V>**
'Edit' 'Delete'	**<Del>**
'Edit' 'Find next'	**<F3>**
'Edit' 'Input Assistant'	**<F2>**
'Edit' 'Next Error'	**<F4>**
'Edit' 'Previous Error'	**<Shift>+<F4>**
'Online' 'Log-in'	**<Alt><F8>**
'Online' 'Logout'	**<Ctrl>+<F8>**
'Online' 'Run'	**<F5>**
'Online' 'Toggle Breakpoint'	**<F9>**
'Online' 'Step over'	**<F10>**
'Online' 'Step in'	**<F8>**
'Online' 'Single Cycle'	**<Ctrl>+<F5>**
'Online' 'Write Values'	**<Ctrl>+<F7>**
'Online' 'Force Values'	**<F7>**
'Online' 'Release Force'	**<Shift>+<F7>**
'Online' "Write/Force dialog'	**<Shift>+<F7>**
'Window' 'Messages'	**<Shift>+<Esc>**
FBD Editor Commands	
'Insert' 'Network (after)'	**<Shift>+<T>**
'Insert' 'Assignment'	**<Ctrl>+<A>**
'Insert' 'Jump'	**<Ctrl>+<L>**
'Insert' 'Return'	**<Ctrl>+<R>**

'Insert' 'Operator'	**<Ctrl>+<O>**
'Insert' 'Function'	**<Ctrl>+<F>**
'Insert' 'Function Block'	**<Ctrl>+<B>**
'Insert' 'Input'	**<Ctrl>+<U>**
'Extras' 'Negate'	**<Ctrl>+<N>**
'Extras' 'Zoom'	**<Alt>+<Enter>**
CFC Editor Commands	
'Insert' 'POU'	**<Ctrl>+<B>**
'Insert' 'Input'	**<Ctrl>+<E>**
'Insert' 'Output'	**<Ctrl>+<A>**
'Insert' 'Jump'	**<Ctrl>+<G>**
'Insert' 'Label'	**<Ctrl>+<L>**
'Insert' 'Return'	**<Ctrl>+<R>**
'Insert' 'Comment'	**<Ctrl>+<K>**
'Insert' 'POU input'	**<Ctrl>+<U>**
'Extras' 'Negate'	**<Ctrl>+<N>**
'Extras' 'Set/Reset'	**<Ctrl>+<T>**
'Extras' 'Connection'	**<Ctrl>+<M>**
'Extras' 'EN/ENO'	**<Ctrl>+<O>**
'Extras' 'Zoom'	**<Alt>+<Enter>**
LD Editor Commands	
'Insert' 'Network (after)'	**<Shift>+<T>**
'Insert' 'Contact'	**<Ctrl>+<O>**
'Insert' 'Parallel Contact'	**<Ctrl>+<R>**
'Insert' 'Function Block'	**<Ctrl>+<B>**
'Insert' 'Coil'	**<Ctrl>+<L>**
'Extras' 'Paste below'	**<Ctrl>+<U>**
'Extras' 'Negate'	**<Ctrl>+<N>**
'Extras' 'Zoom'	**<Alt>+<Enter>**
SFC Editor Commands	
'Insert' 'Step-Transition (before)'	**<Ctrl>+<T>**
'Insert' 'Step-Transition (after)'	**<Ctrl>+<E>**
'Insert' 'Alternative Branch (right)'	**<Ctrl>+<A>**
'Insert' 'Parallel Branch (right)'	**<Ctrl>+<L>**
'Insert' 'Jump'	**<Ctrl>+<U>**

'Extras' 'Zoom Action/Transition'	**<Alt>+<Enter>**
Move back to the editor from the SFC Overview	**<Enter>**
Work with the PLC Configuration	
Open and close organization elements	**<Enter>**
Place an edit control box around the name	**<Spacebar>**
'Extras' 'Edit Entry'	**<Enter>**
Work with the Task Configuration	
Place an edit control box around the task- or filename	**<Spacebar>**

11 Data Types

11.1 Standard Data types

11.1.1.1 Data types

You can use standard data types and user-defined data types when programming. Each identifier is assigned to a data type which dictates how much memory space will be reserved and what type of values it stores.

11.1.1.2 BOOL

BOOL type variables may be given the values TRUE and FALSE. 8 bits of memory space will be reserved.

(see also: BOOL constants)

11.1.1.3 Integer Data Types

BYTE, **WORD**, **DWORD**, **SINT**, **USINT**, **INT**, **UINT**, **DINT**, and **UDINT** are all integer data types.

Each of the different number types covers a different range of values. The following range limitations apply to the integer data types:

Type	Lower limit	Upper limit	Memory space
BYTE	0	255	8 Bit
WORD	0	65535	16 Bit
DWORD	0	4294967295	32 Bit
SINT:	-128	127	8 Bit
USINT:	0	255	8 Bit
INT:	-32768	32767	16 Bit
UINT:	0	65535	16 Bit
DINT:	-2147483648	2147483647	32 Bit
UDINT:	0	4294967295	32 Bit

As a result when larger types are converted to smaller types, information may be lost.

see also : Numerical Constants

11.1.1.4 REAL

REAL is a so-called floating-point type. **REAL** is required to represent rational numbers. 32 bits of memory space is reserved for REAL.

see also Appendix F: REAL constants

11.1.1.5 STRING

A **STRING** type variable can contain any string of characters. The size entry in the declaration determines how much memory space should be reserved for the variable. It refers to the number of characters in the string and can be placed in parentheses or square brackets. If no size specification is given, the default size of 80 characters will be used.

Example of a String Declaration with 35 characters:

```
str:STRING(35):='This is a String';
```

see also : STRING constants

11.1.1.6 Time Data Types

The data types **TIME**, **TIME_OF_DAY** (abb. **TOD**), **DATE** and **DATE_AND_TIME** (abb. **DT**) are handled internally like DWORD.

Time is given in milliseconds in TIME and TOD, time in TOD begins at 12:00 A.M.

Time is given in seconds in DATE and DT beginning with January 1, 1970 at 12:00 A.M.

See in the following the time data formats used to assign values for time constants:

TIME constants:

always made up of an initial "t" or "T" (or "time" or "TIME" spelled out) and a number sign "#".

This is followed by the actual time declaration which can include days (identified by "d"), hours (identified by "h"), minutes (identified by "m"), seconds (identified by "s") and milliseconds (identified by "ms"). Please note that the time entries must be given in this order according to length (d before h before m before s before m before ms) but you are not required to include all time increments.

Examples of correct TIME constants in a ST assignment:

```
TIME1 := T#14ms;
```

```
TIME1 := T#100S12ms;  (*The highest component may be
     allowed to exceed its limit*)

TIME1 := t#12h34m15s;
```

the following would be incorrect:

```
TIME1 := t#5m68s;     (*limit exceeded in a lower
     component*)

TIME1 := 15ms;        (*T# is missing*)

TIME1 := t#4ms13d;    (*Incorrect order of entries*)
```

DATE Constants:

beginning with a "d", "D", "DATE" or "date" followed by "#". You can then enter any date with format Year-Month-Day.

Examples:

```
DATE#1996-05-06

d#1972-03-29
```

TIME_OF_DAY Constants, for storing times of the day:

begin with "tod#", "TOD#", "TIME_OF_DAY#" or "time_of_day#" followed by a time with the format: Hour:Minute:Second. Seconds can be entered as real numbers or you can enter fractions of a second.

Examples:

```
TIME_OF_DAY#15:36:30.123

tod#00:00:00
```

DATE_AND_TIME Constants, combination of date and the time of day:

begin with "dt#", "DT#", "DATE_AND_TIME#" or "date_and_time#". Place a hyphen after the date followed by the time.

Examples:

```
DATE_AND_TIME#1996-05-06-15:36:30

dt#1972-03-29-00:00:00
```

11.2 Defined Data Types

11.2.1.1 ARRAY

One-, two-, and three-dimensional fields (arrays) are supported as elementary data types. Arrays can be defined both in the declaration part of a POU and in the global variable lists.

Syntax:

```
<Field_Name>:ARRAY [<ll1>..<ul1>,<ll2>..<ul2>] OF
      <elem. Type>.
```

ll1, ll2, ll3 identify the lower limit of the field range; ul1, ul2 and ul3 identify the upper limit. The range values must be integers.

Example:

```
Card_game: ARRAY [1..13, 1..4] OF INT;
```

Initializing Arrays:

Example for complete initialization of an array:

```
arr1 : ARRAY [1..5] OF INT := 1,2,3,4,5;

arr2 : ARRAY [1..2,3..4] OF INT := 1,3(7);
      (* short for 1,7,7,7 *)

arr3 : ARRAY [1..2,2..3,3..4] OF INT := 2(0),4(4),2,3;
      (* short for 0,0,4,4,4,4,2,3 *)
```

Example of the initialization of an array of a structure:

```
TYPE STRUCT1

STRUCT

p1:int;

p2:int;

p3:dword;

END_STRUCT

ARRAY[1..3] OF STRUCT1:=
      (p1:=1;p2:=10;p3:=4723),(p1:=2;p2:=0;p3:=299),
      (p1:=14;p2:=5;p3:=112);
```

Example of the partial initialization of an Array:

```
arr1 : ARRAY [1..10] OF INT := 1,2;
```

Elements to which no value is pre-assigned are initialized with the default initial value of the basic type. In the example above, the elements anarray[6] to anarray[10] are therefore initialized with 0.

Array components are accessed in a two-dimensional array using the following syntax:

```
<Field_Name>[Index1,Index2]
```

Example:

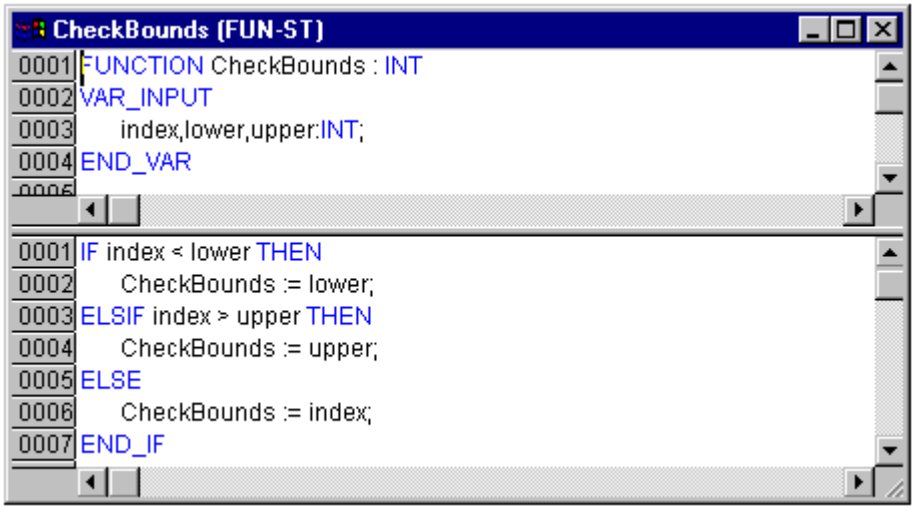
```
Card_game [9,2]
```

Note:
If you define a function in your project with the name CheckBounds, you can use it to check for range overflows in your project (see chapter 'What is what in **WAGO-I/O-*PRO* 32**', 'Components of a project', 'Function')

11.2.1.2 Function Checkbounds

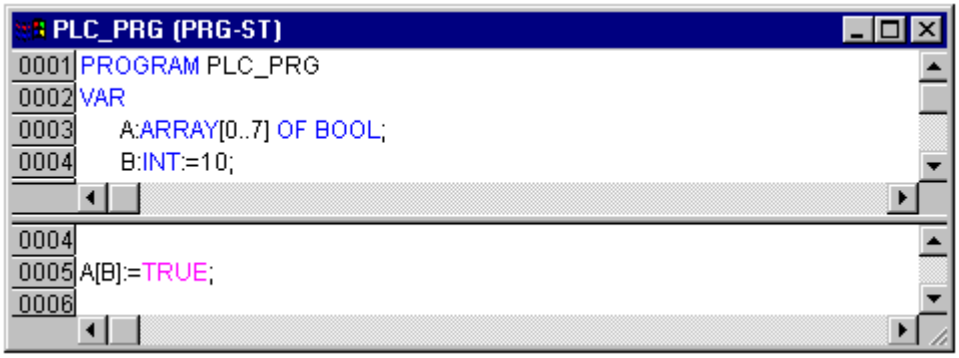
If you define a function in your project with the name **CheckBounds**, you can automatically check for out-of-range errors in arrays. The name of the function is fixed and can only have this designation.

X Example for the CheckBounds function



The following sample program for testing the CheckBounds function exceeds the bounds of a defined array. The CheckBounds function allows the value TRUE to be assigned, not to location A[10], but to the still valid range boundary A[7] above it. With the CheckBounds function, references outside of array boundaries can thus be corrected.

X Test Program for the CheckBounds Function



11.2.1.3 Pointer

Variable or function block addresses are saved in pointers while a program is running.

Pointer declarations have the following syntax:

```
<Identifier>: POINTER TO <Datatype/Functionblock>;
```

A pointer can point to any data type or function block even to user-defined types.

The function of the Address Operator ADR is to assign the address of a variable or function block to the pointer.

A pointer can be dereferenced by adding the content operator "^" after the pointer identifier.

Example:

```
pt:POINTER TO INT;

var_int1:INT := 5;

var_int2:INT;

pt := ADR(var_int1);

var_int2:= pt^; (* var_int2 is now 5 *)
```

11.2.1.4 Enumeration

Enumeration is a user-defined data type that is made up of a number of string constants. These constants are referred to as enumeration values.

Enumeration values are recognized in all areas of the project even if they were declared within a POU. It is best to create your enumerations as

objects in the Object Organizer under the register card **Data types**. They begin with the keyword TYPE and end with END_TYPE.

Syntax:

```
TYPE <Identifier>:(<Enum_0> ,<Enum_1>, ...,<Enum_n>);

END_TYPE
```

A variable of the type <Identifier> can take on one of the enumeration values and will be initialized with the first one. These values are compatible with whole numbers which means that you can perform operations with them just as you would with INT. You can assign a number x to the variable. If the enumeration values are not initialized, counting will begin with 0. When initializing, make certain the initial values are increasing. The validity of the number will be reviewed at the time it is run.

Example:

```
TYPE TRAFFIC_SIGNAL: (Red, Yellow, Green:=10); (*The
     initial value for each of the colors is red 0,
     yellow 1, green 10 *)

END_TYPE

TRAFFIC_SIGNAL1 : TRAFFIC_SIGNAL;

TRAFFIC_SIGNAL1:=0; (* The value of the traffic signal
     is red*)

FOR i:= Red TO Green DO

     i := i + 1;

END_FOR;
```

The same enumeration value could not be used twice. Example:

Example:

```
TRAFFIC_SIGNAL: (red, yellow, green);

COLOR: (blue, white, red);

Error: red may not be used for both TRAFFIC_SIGNAL and
     COLOR.
```

11.2.1.5 Structures

Structures are created as objects in the Object Organizer under the register card **Data types**. They begin with the keywords TYPE and STRUCT and end with END_STRUCT and END_TYPE.

The syntax for structure declarations is as follows:

```
TYPE <Structurename>:

STRUCT
```

```
        <Declaration of Variables 1>

        .

        .

        <Declaration of Variables n>

END_STRUCT

END_TYPE
```

<Structurename> is a type that is recognized throughout the project and can be used like a standard data type.

Interlocking structures are allowed. The only restriction is that variables may not be placed at addresses (the AT declaration is not allowed!).

Example for a structure definition named Polygonline:

```
TYPE Polygonline:

STRUCT

        Start:ARRAY [1..2] OF INT;

        Point1:ARRAY [1..2] OF INT;

        Point2:ARRAY [1..2] OF INT;

        Point3:ARRAY [1..2] OF INT;

        Point4:ARRAY [1..2] OF INT;

        End:ARRAY [1..2] OF INT;

END_STRUCT

END_TYPE
```

Example for the initialization of a structure:

```
Poly_1:polygonline := ( Start:=3,3, Point1 =5,2,
        Point2:=7,3, Point3:=8,5, Point4:=5,7, End :=
        3,5);
```

Initializations with variables are not possible. See an example of the initialization of an array of a structure under 'Arrays'.

You can gain access to structure components using the following syntax:

```
<Structure_Name>.<Componentname>
```

For example, if you have a structure named "Week" that contains a component named "Monday", you can get to it by doing the following:

```
Week.Monday
```

11.2.1.6 References

You can use the user-defined reference data type to create an alternative name for a variable, constant or function block.

Create your references as objects in the Object Organizer under the register card **Data types**. They begin with the keyword TYPE and end with END_TYPE.

Syntax:

```
TYPE <Identifier>: <Assignment term>;

END_TYPE
```

Example:

```
TYPE message:STRING[50];

END_TYPE;
```

11.2.1.7 Subrange types

A subrange type is a type whose range of values is only a subset of that of the basic type. The declaration can be carried out in the data types register, but a variable can also be directly declared with a subrange type:

Syntax for the declaration in the 'Data types' register:

TYPE <Name> : <Inttype> (<ug>..<og>) END_TYPE;

<Name> must be a valid IEC identifier,

<Inttype> is one of the data types SINT, USINT, INT, UINT, DINT, UDINT, BYTE, WORD, DWORD (LINT, ULINT, LWORD).

<ug> Is a constant which must be compatible with the basic type and which sets the lower boundary of the range types. The lower boundary itself is included in this range.

<og> Is a constant that must be compatible with the basic type, and sets the upper boundary of the range types. The upper boundary itself is included in this basic type.

Examples:

```
TYPE

      SubInt : INT (-4095..4095);
```

```
END_TYPE
```

Direct declaration of a variable with a subrange type:

```
VAR

      i : INT (-4095..4095);

      ui : UINT (0..10000);

END_VAR
```

If a constant is assigned to a subrange type (in the declaration or in the implementation) that does not fall into this range (e.g. 1:=5000), an error message is issued.

In order to check for observance of range boundaries at runtime, the functions **CheckRangeSigned** or **CheckRangeUnsigned** must be introduced. In these, boundary violations can be captured by the appropriate method and means (e.g. the value can be cut out or an error flag can be set.). They are implicitly called as soon as a variable is written as belonging to a subrange type constructed from either a signed or an unsigned type.

Example: In the case of a variable belonging to a signed subrange type (like i, above), the function CheckRangeSigned is called; it could be programmed as follows to trim a value to the permissible range:

```
FUNCTION CheckRangeSigned : DINT

VAR_INPUT

      value, lower, upper: DINT;

END_VAR

IF (value < lower) THEN

      CheckRangeSigned := lower;

ELSIF(value > upper) THEN

      CheckRangeSigned := upper;

ELSE

      CheckRangeSigned := value;

END_IF
```

In calling up the function automatically, the function name CheckRangeSigned is obligatory, as is the interface specification: return value and three parameters of type DINT

When called, the function is parameterized as follows:

- value: the value to be assigned to the range type
- lower: the lower boundary of the range
- upper: the upper boundary of the range
- Return value: this is the value that is actually assigned to the range type

An assignment i:=10*y implicitly produces the following in this example:

```
i := CheckRangeSigned(10*y, -4095, 4095);
```

Even if y for example has the value 1000, then i still has only the value 4095 after this assignment.

The same applies to the function CheckRangeUnsigned: function name and interface must be correct.

```
FUNCTION CheckRangeUnsigned : UDINT

VAR_INPUT

      value, lower, upper: UDINT;

END_VAR
```

Note:
If neither of the functions CheckRangeSigned or CheckRangeUnsigned is present, no type checking of subrange types occurs during runtime! The variable i could then take on any value between –32768 and 32767 at any time!

Attention:
If neither of the functions CheckRangeSigned or CheckRangeUnsigned is present like described above, there can result an endless loop if a subrange type is used in a **FOR** loop. This will happen when the range given for the FOR loop is as big or bigger than the range of the subrange type !

Example:

```
VAR

      ui : UINT (0..10000);

END_VAR


FOR ui:=0 TO 10000 DO

...

END_FOR
```

The FOR loop will never be finished, because ui cannot get bigger than 10000.

Also take care of the definition of the CheckRange functions when you define the incremental value of a FOR loop !

12 The IEC Operators

12.1 The IEC Operators

WAGO-I/O-*PRO* 32 supports all IEC operators. In contrast with the standard library functions (see appendix D, Standard library), these operators are recognized implicitly throughout the project. Operators are used like functions in POU. The following categories of operators are supported:

12.2 Arithmetic Operators

12.2.1 ADD

Addition of variables of the types: BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT and REAL.

Two TIME variables can also be added together resulting in another time (e.g., t#45s + t#50s = t#1m35s)

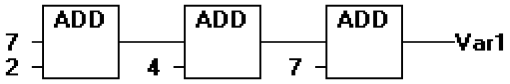
Example in IL:

```
LD    7

ADD   2,4,7

ST    Var 1
```

Example in ST:

```
var1 := 7+2+4+7;
```

Example in FBD:



12.2.2 MUL

Multiplication of variables of the types: BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT and REAL.

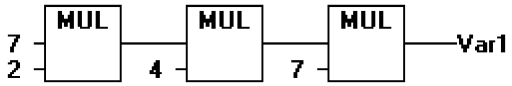
Example in IL:

```
LD    7

MUL   2,4,7

ST    Var 1
```

Example in ST:

```
var1 := 7*2*4*7;
```

Example in FBD:



12.2.3 SUB

Subtraction of one variable from another of the types: BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT and REAL.

A TIME variable may also be subtracted from another TIME variable resulting in third TIME type variable. Note that negative TIME values are undefined.

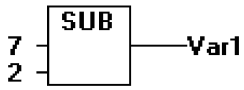
Example in IL:

```
LD    7

SUB   8

ST    Var 1
```

Example in ST:

```
var1 := 7-2;
```

Example in FBD:



12.2.4 DIV

Division of one variable by another of the types: BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT and REAL.

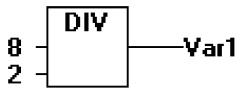
Example in IL:

```
LD    8

DIV   2

ST    Var1  (* Result is 4 *)
```

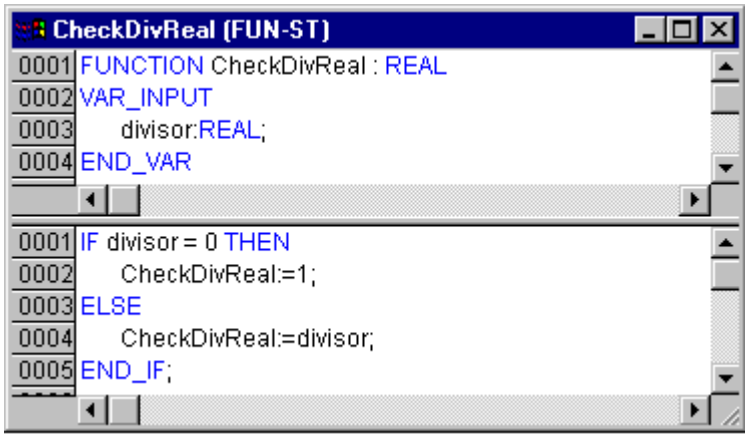
Example in ST:

```
var1 := 8/2;
```

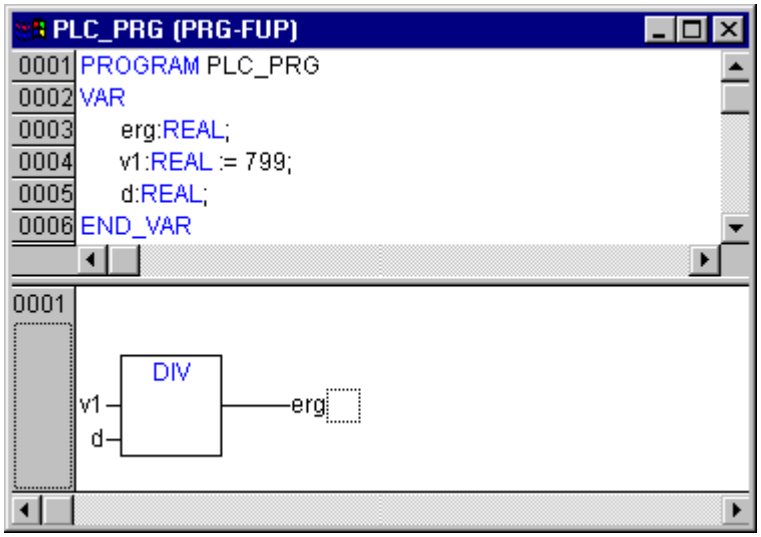
Example in FBD:



Note:
If you define functions in your project with the names **CheckDivByte**, **CheckDivWord**, **CheckDivDWord** and **CheckDivReal**, you can use them to check the value of the divisor if you use the operator DIV, for example to avoid a division by 0. The functions must have the above listed names. See in the following an example for the implementation of function CheckDivReal:



Operator DIV uses the output of function CheckDivReal as divisor. In a program like shown in the following example this avoids a division by 0, the divisor (d) is set from 0 to 1. So the result of the division is 799.



12.2.5 MOD

Modulo Division of one variable by another of the types: BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT. The result of this function will be the remainder of the division. This result will be a whole number.

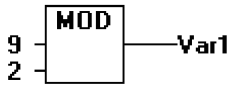
Example in IL:

```
LD    9

MOD   2

ST    Var1  (* Result is 1 *)
```

Example in ST:

```
var1 := 9 MOD 2;
```

Example in FBD:



12.2.6 INDEXOF

Perform this function to find the internal index for a POU.

Example in ST:

```
var1 := INDEXOF(POU2);
```

12.2.7 SIZEOF

Perform this function to determine the number of bytes required by the given data type.

Example in IL:

```
arr1:ARRAY[0..4] OF INT;

Var1  INT

LD    arr1

SIZEOF

ST    Var1  (* Result is 10 *)
```

Example in ST:

```
var1 := SIZEOF(arr1);
```

12.3 Bitstring Operators

12.3.1 AND

Bitwise AND of bit operands. The operands should be of the type BOOL, BYTE, WORD or DWORD.

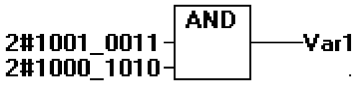
Example in IL:

```
Var1  BYTE

LD    2#1001_0011

AND   2#1000_1010

ST    Var1  (* Result is 2#1000_0010 *)
```

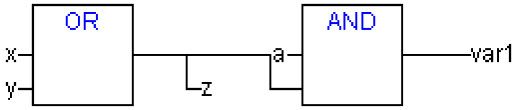
Example in ST:

```
var1 := 2#1001_0011 AND 2#1000_1010
```

Example in FBD:



Note:
If you have a program step in the SFC like the following



and if you use 68xxx- or C-code generators, please note the following: The allocation of the value of the second input variable at the AND operator module to variable z will not be executed ! This is due to the optmized processing in the SFC in case of value FALSE at the input variable.

12.3.2 OR

Bitwise OR of bit operands. The operands should be of the type BOOL, BYTE, WORD or DWORD.

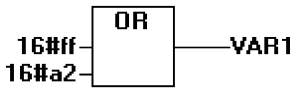
Example in IL:

```
var1 :BYTE;

LD    2#1001_0011

OR    2#1000_1010

ST    var1  (* Result is 2#1001_1011 *)
```

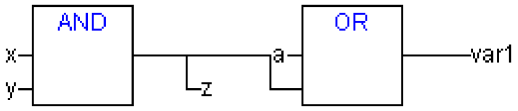
Example in ST:

```
Var1 := 2#1001_0011 OR 2#1000_1010
```

Example in FBD:



Note:
If you have a program step in the SFC like the following



and if you use 68xxx- or C-code generators, please note the following: The allocation of the value of the second input variable at the AND operator module to variable z will not be executed ! This is due to the optmized processing in the SFC in case of value FALSE at the input variable.

12.3.3 XOR

Bitwise XOR of bit operands. The operands should be of the type BOOL, BYTE, WORD or DWORD.

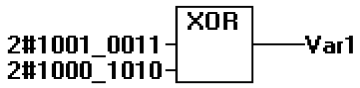
Example in IL:

```
Var1 :BYTE;

LD    2#1001_0011

XOR   2#1000_1010

ST    Var1  (* Result is 2#0001_1001 *)
```

Example in ST:

```
Var1 := 2#1001_0011 XOR 2#1000_1010
```

Example in FBD:



12.3.4 NOT

Bitwise NOT of a bit operand. The operand should be of the type BOOL, BYTE, WORD or DWORD.

Example in IL:

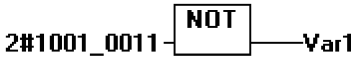
```
Var1 :BYTE;

LD    2#1001_0011

NOT
```

```
ST    Var1  (* Result is 2#0110_1100 *)
```

Example in ST:

```
Var1 := NOT 2#1001_0011
```

Example in FBD:



12.4 Bit-Shift Operators

Note:
The code generator for the Infineon C16x target system carries out bit-shift calculating operations with modulo 16.

12.4.1 SHL

Bitwise left-shift of an operand : erg:= SHL (in, n)

The input variables erg, in and n should be of the type BYTE, WORD, or DWORD. in will be shifted to the left by n bits and filled with zeros on the right.

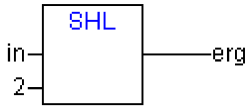
Note:
Please note, that the amount of bits, which is regarded for the arithmetic operation, is pretended by the data type of the input variable !. If the input variable is a constant the smallest possible data type is regarded. The data type of the output variable has no effect at all on the arithmetic operation.

See in the following example in hexadecimal notation that you get different results for erg_byte and erg_word depending on the data type of the input variable (BYTE or WORD), although the values of the input variables in_byte and in_word are the same.

Example in ST:

```
shl_st (PRG-ST)
0001 PROGRAM shl_st
0002 VAR
0003     in_byte:BYTE:=16#45;
0004     in_word:WORD:=16#45;
0005     erg_byte: BYTE;
0006     erg_word: WORD;
0007     n:BYTE:=2;
0008 END_VAR

0001
0002 erg_byte:=SHL (in_byte,n);    (* Ergebnis ist 16#14*)
0003 erg_word:=SHL (in_word,n); (* Ergebnis ist 16#0114 *)
0004
```

Example in FBD:



Example in IL:

```
LD    16#45

SHL   2

ST    erg_byte
```

12.4.2 SHR

Bitwise right-shift of an operand: erg:= SHR (in, n)

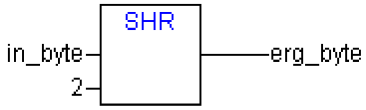
erg, in and n should be of the type BYTE, WORD or DWORD. in will be shifted to the right by n bits and filled with zeros on the left.

See the following example in hexadecimal notation to notice the results of the arithmetic operation depending on the type of the input variable (BYTE or WORD).

Example in ST:

```
shr_st (PRG-ST)
0001 PROGRAM shr_st
0002 VAR
0003     in_byte:BYTE:=16#45;
0004     in_word:WORD:=16#45;
0005     erg_byte: BYTE;
0006     erg_word: WORD;
0007     n:BYTE:=2;
0008 END_VAR

0001
0002 erg_byte:=SHR (in_byte,n);    (* Ergebnis ist 11*)
0003 erg_word:=SHR (in_word,n); (* Ergebnis ist 0011*)
0004
```

Example in FBD:



Example in IL:

```
LD    16#45

SHL   2

ST    erg_byte
```

12.4.3 ROL

Bitwise rotation of an operand to the left: erg:= ROL (in, n)

erg, in and n should be of the type BYTE, WORD or DWORD. in will be shifted one bit position to the left n times while the bit that is furthest to the left will be reinserted from the right.

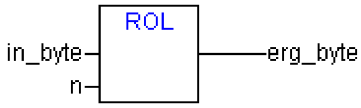
Note:
Please note, that the amount of bits, which is regarded for the arithmetic operation, is pretended by the data type of the input variable !. If the input variable is a constant the smallest possible data type is regarded. The data type of the output variable has no effect at all on the arithmetic operation.

See in the following example in hexadecimal notation that you get different results for erg_byte and erg_word depending on the data type of the input variable (BYTE or WORD), although the values of the input variables in_byte and in_word are the same.

Example in ST:

```
rol_st (PRG-ST)
0001 PROGRAM rol_st
0002 VAR
0003     in_byte:BYTE:=16#45;
0004     in_word:WORD:=16#45;
0005     erg_byte: BYTE;
0006     erg_word: WORD;
0007     n:BYTE:=2;
0008 END_VAR

0001
0002 erg_byte:= ROL (in_byte,n);   (* Ergebnis ist 16#15 *))
0003 erg_word:=ROL (in_word,n);  (* Ergebnis ist 16#0114 *)
```

Example in FBD:



Example in IL:

```
LD    16#45

SHL   2

ST    erg_byte
```

12.4.4 ROR

Bitwise rotation of an operand to the right: erg = ROR (in, n)

erg, in and n should be of the type BYTE, WORD or DWORD. in will be shifted one bit position to the right n times while the bit that is furthest to the left will be reinserted from the left.

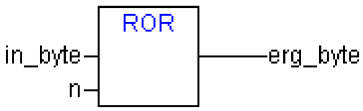
Note:
Please note, that the amount of bits, which is regarded for the arithmetic operation, is pretended by the data type of the input variable !. If the input variable is a constant the smallest possible data type is regarded. The data type of the output variable has no effect at all on the arithmetic operation.

See in the following example in hexadecimal notation that you get different results for erg_byte and erg_word depending on the data type of the input variable (BYTE or WORD), although the values of the input variables in_byte and in_word are the same.

Example in ST:

```
ror_st (PRG-ST)
0001 PROGRAM ror_st
0002 VAR
0003     in_byte:BYTE:=16#45;
0004     in_word:WORD:=16#45;
0005     erg_byte: BYTE;
0006     erg_word: WORD;
0007     n:BYTE:=2;
0008 END_VAR

0001
0002 erg_byte:= ROR (in_byte,n);   (* Ergebnis ist 16#51 *)
0003 erg_word:=ROR (in_word,n); (* Ergebnis ist 16#4011 *)
```

Example in FBD:



Example in IL:

```
LD    16#45

SHL   2

ST    erg_byte
```

12.5 Selection Operators

All selection operations can also be performed with variables. For purposes of clarity we will limit our examples to the following which use constants as operators.

12.5.1 SEL

Binary Selection.

```
OUT := SEL(G, IN0, IN1) means:

OUT := IN0 if G=FALSE;

OUT := IN1 if G=TRUE.
```

IN0, IN1 and OUT can be any type of variable, G must be BOOL. The result of the selection is IN0 if G is FALSE, IN1 if G is TRUE.

Example in IL:

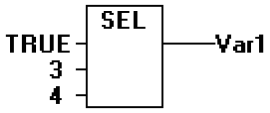
```
LD    TRUE

SEL   3,4
```

```
ST    Var1  (* Result ist 4 *)

LD    FALSE

SEL   3,4

ST    Var1  (* Result ist 3 *)
```

Example in ST:

```
Var1:=SEL(TRUE,3,4);    (* Result is 4 *)
```

Example in FBD:



Note:
Note that an expression occurring ahead of IN1 or IN2 will not be processed if IN0 is TRUE.

12.5.2 MAX

Maximum function. Returns the greater of the two values.

```
OUT := MAX(IN0, IN1)
```

IN0, IN1 and OUT can be any type of variable.

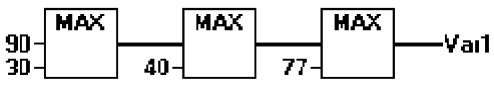
Example in IL:

```
LD    90

MAX   30

MAX   40

MAX   77

ST    Var1  (* Result is 90 *)
```

Example in ST:

```
Var1:=MAX(30,40);    (* Result is 40 *)

Var1:=MAX(40,MAX(90,30));    (* Result is 90 *)
```

Example in FBD:



12.5.3 MIN

Minimum function. Returns the lesser of the two values.

```
OUT := MIN(IN0, IN1)
```

IN0, IN1 and OUT can be any type of variable.

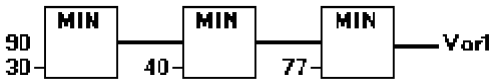
Example in IL:

```
LD    90
MIN   30
MIN   40
MIN   77
ST    Var1  (* Result is 30 *)
```

Example in ST:

```
Var1:=MIN(90,30);  (* Result is 30 *);
Var1:=MIN(MIN(90,30),40);  (* Result is 30 *);
```

Example in FBD:



12.5.4 LIMIT

Limiting

```
OUT := LIMIT(Min, IN, Max) means:
OUT := MIN (MAX (IN, Min), Max)
```

Max is the upper and Min the lower limit for the result. Should the value IN exceed the upper limit Max, LIMIT will return Max. Should IN fall below Min, the result will be Min.

IN and OUT can be any type of variable.

Example in IL:

```
LD    90
LIMIT 30,80
ST    Var1  (*Result is 80 *)
```

Example in ST:

```
Var1:=LIMIT(30,90,80);  (* Result is 80 *);
```

12.5.5 MUX

Multiplexer

```
OUT := MUX(K, IN0,...,INn) means:

OUT := INK.
```

IN0, ...,INn and OUT can be any type of variable. K must be BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT or UDINT. MUX selects the Kth value from among a group of values.

Example in IL:

```
LD    0

MUX   30,40,50,60,70,80

ST    Var1  (*Result is 30 *)
```

Example in ST:

```
Var1:=MUX(0,30,40,50,60,70,80);  (* Result is 30 *);
```

Note:
Note that an expression occurring ahead of an input other than INK will not be processed to save run time ! Only in simulation mode all expressions will be executed.

12.6 Comparison Operators

12.6.1 GT

Greater than

A Boolean operator which returns the value TRUE when the value of the first operand is greater than that of the second. The operands can be BOOL, BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT, REAL, TIME, DATE, TIME_OF_DAY, DATE_AND_TIME and STRING.

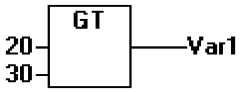
Example in IL:

```
LD    20

GT    30

ST    Var1  (* Result is FALSE *)
```

Example in ST:

```
VAR1 := 20 > 30 > 40 > 50 > 60 > 70;
```

Example in FBD:



12.6.2 LT

Less than

A Boolean operator that returns the value TRUE when the value of the first operand is less than that of the second. The operands can be BOOL, BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT, REAL, TIME, DATE, TIME_OF_DAY, DATE_AND_TIME and STRING.

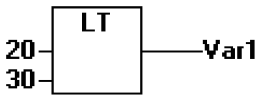
Example in IL:

```
LD    20

LT    30

ST    Var1  (* Result is TRUE *)
```

Example in ST:

```
VAR1 := 20 < 30;
```

Example in FBD:



12.6.3 LE

Less than or equal to

A Boolean operator that returns the value TRUE when the value of the first operand is less than or equal to that of the second. The operands can be BOOL, BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT, REAL, TIME, DATE, TIME_OF_DAY, DATE_AND_TIME and STRING.

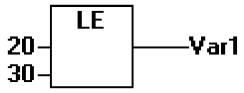
Example in IL:

```
LD    20

LE    30

ST    Var1  (* Result is TRUE *)
```

Example in ST:

```
VAR1 := 20 <= 30;
```

Example in FBD



12.6.4 GE

Greater than or equal to

A Boolean operator that returns the value TRUE when the value of the first operand is greater than or equal to that of the second. The operands can be BOOL, BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT, REAL, TIME, DATE, TIME_OF_DAY, DATE_AND_TIME and STRING.

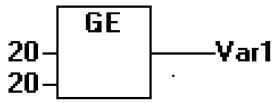
Example in IL:

```
LD    60

GE    40

ST    Var1  (* Result is TRUE *)
```

Example in ST:

```
VAR1 := 60 >= 40;
```

Example in FBD:



12.6.5 EQ

Equal to

A Boolean operator that returns the value TRUE when the operands are equal. The operands can be BOOL, BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT, REAL, TIME, DATE, TIME_OF_DAY, DATE_AND_TIME and STRING.

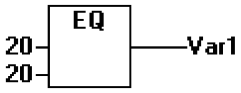
Example in IL:

```
LD    40

EQ    40

ST    Var1  (* Result is TRUE *)
```

Example in ST:

```
VAR1 := 40 = 40;
```

Example in FBD:



12.6.6 NE

Not equal to

A Boolean operator that returns that value TRUE when the operands are not equal. The operands can be BOOL, BYTE, WORD, DWORD, SINT, USINT, INT, UINT, DINT, UDINT, REAL, TIME, DATE, TIME_OF_DAY, DATE_AND_TIME and STRING.

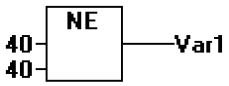
Example in IL:

```
LD    40
NE    40
ST    Var1  (* Result is FALSE *)
```

Example in ST:

```
VAR1 := 40 <> 40;
```

Example in FBD:



12.7 Address Operators

12.7.1 ADR

Address Function

ADR returns the address of its argument in a DWORD. This address can be sent to manufacturing functions to be treated as a pointer or it can be assigned to a pointer within the project.

Example in IL:

```
LD    Var1
ADR
ST    Var2
```

```
man_fun1
```

12.7.2 Content Operator

A pointer can be dereferenced by adding the content operator "^" after the pointer identifier.

Example in ST:

```
pt:POINTER TO INT;

var_int1:INT;

var_int2:INT;

pt := ADR(var_int1);

var_int2:=pt^;
```

12.8 Calling Operator

12.8.1 CAL

Calling a function block or a program

Use CAL in IL to call up a function block instance. The variables that will serve as the input variables are placed in parentheses right after the name of the function block instance.

Example: Calling up the instance *Inst* from a function block where input variables *Par1* and *Par2* are 0 and TRUE respectively.

```
CAL INST(PAR1 := 0, PAR2 := TRUE)
```

12.9 Type Conversion Functions

Its is forbidden to implicitly convert from a "larger" type to a "smaller" type (for example from INT to BYTE or from DINT to WORD). Special type conversions are required if one wants to do this. One can basically convert from any elementary type to any other elementary type.

Syntax:

```
<elem.Typ1>_TO_<elem.Typ2>
```

Please regard that at ...TO_STRING conversions the string is generated left-justified. If it is defined to short, it will be cut from the right side.

12.9.1 BOOL_TO Conversions

Conversion from type BOOL to any other type:

For number types the result is 1, when the operand is TRUE, and 0, when the operand is FALSE.

For the STRING type the result is ‚TRUE' or ‚FALSE'.

Examples in AWL:

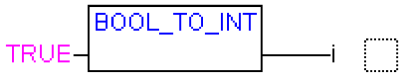
```
LD    TRUE

BOOL_TO_INT

ST    i     (*Result is 1 *)

LD    TRUE

BOOL_TO_STRING

ST    str   (*Result is 'TRUE' *)

LD    TRUE

BOOL_TO_TIME

ST    t     (*Result is T#1ms *)

LD    TRUE

BOOL_TO_TOD

ST    tof   (*Result is TOD#00:00:00.001 *)

LD    FALSE

BOOL_TO_DATE

ST    dat   (*Result is D#1970-01-01 *)

LD    TRUE

BOOL_TO_DT

ST    dandt (*Result is DT#1970-01-01-00:00:01 *)
```

Examples in St:

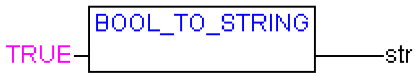
```
i:=BOOL_TO_INT(TRUE);       (* Result is 1 *)

str:=BOOL_TO_STRING(TRUE); (* Result is "TRUE" *)

t:=BOOL_TO_TIME(TRUE);      (* Result is T#1ms *)

tof:=BOOL_TO_TOD(TRUE);     (* Result is
     TOD#00:00:00.001 *)

dat:=BOOL_TO_DATE(FALSE);   (* Result is D#1970 *)
```

```
dandt:=BOOL_TO_DT(TRUE);    (* Result is DT#1970-01-01-
      00:00:01 *)
```

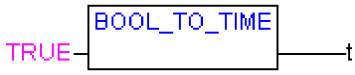
Examples in FUP:



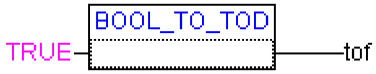

```
(*Result is 1 *)
```



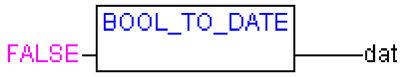

```
(*Result is 'TRUE' *)
```



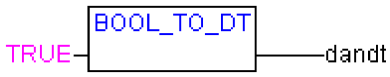

```
(*Result is T#1ms *)
```




```
(*Result is TOD#00:00:00.001
*)
```




```
(*Result is D#1970-01-01 *)
```




```
(*Result is DT#1970-01-01-
00:00:01 *)
```

12.9.2 TO_BOOL Conversions

Conversion from another variable type to BOOL:

The result is TRUE when the operand is not equal to 0. The result is FALSE when the operand is equal to 0.

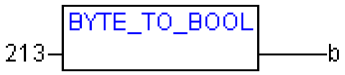
The result is true for STRING type variables when the operand is "TRUE", otherwise the result is FALSE.

Examples in AWL:

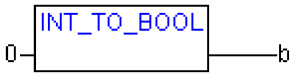
```
LD    213

BYTE_TO_BOOL

ST    b     (*Result is TRUE *)

LD    0

INT_TO_BOOL

ST    b     (*Result is FALSE *)

LD    T#5ms
```

```
TIME_TO_BOOL

ST    b     (*Result is TRUE *)

LD    'TRUE'

STRING_TO_BOOL

ST    b     (*Result is TRUE *)
```

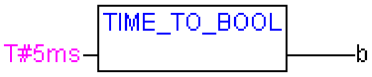
Examples in FUP:



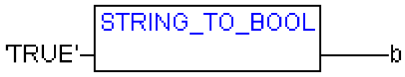
(*Result is TRUE *)



(*Result is FALSE *)



(*Result is TRUE *)



(*Result is TRUE *)

Examples in St:

```
b := BYTE_TO_BOOL(2#11010101);   (* Result is TRUE *)

b := INT_TO_BOOL(0);             (* Result is FALSE *)

b := TIME_TO_BOOL(T#5ms);        (* Result is TRUE *)

b := STRING_TO_BOOL('TRUE');     (* Result is TRUE *)
```

12.9.3 Conversion between Integral Number Types

Conversion from an integral number type to another number type:

When you perform a type conversion from a larger to a smaller type, you risk losing some information. If the number you are converting exceeds the range limit, the first bytes for the number will be ignored.

Example in ST:

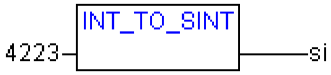
```
si := INT_TO_SINT(4223); (* Result is 127 *)
```

If you save the integer 4223 (16#107f represented hexadecimally) as a SINT variable, it will appear as 127 (16#7f represented hexadecimally).

Example in IL:

```
LD    2

INT_TO_REAL

MUL   3.5
```

Example in FBD:



12.9.4 REAL_TO Conversions

Converting from the variable type REAL to a different type:

The value will be rounded up or down to the nearest whole number and converted into the new variable type. Exceptions to this are the variable types STRING, BOOL and REAL.

Please regard at a conversion to type STRING that the total number of digits is limited to 16. If the (L)REAL-number has more digits, then the sixteenth will be rounded. If the length of the STRING is defined to short, it will be cut beginning from the right end.

When you perform a type conversion from a larger to a smaller type, you risk losing some information.

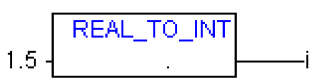
Example in ST:

```
i := REAL_TO_INT(1.5);      (* Result is 2 *)

j := REAL_TO_INT(1.4);      (* Result is 1 *)

i := REAL_TO_INT(-1.5);     (* result is -2 *)

j := REAL_TO_INT(-1.4);     (* result is -1 *)
```

Example in IL:

```
LD    2.7

REAL_TO_INT

GE    %MW8
```

Example in FBD:



12.9.5 TIME_TO/TIME_OF_DAY Conversions

Converting from the variable type TIME or TIME_OF_DAY to a different type:

The time will be stored internally in a DWORD in milliseconds (beginning with 12:00 A.M. for the TIME_OF_DAY variable). This value will then be converted.

When you perform a type conversion from a larger to a smaller type, you risk losing some information

For the STRING type variable, the result is a time constant.

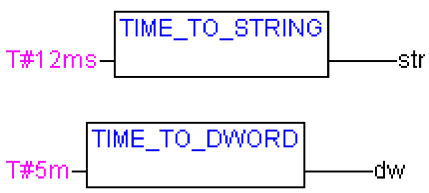
Examples in IL:

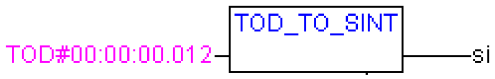
```
LD    T#12ms

TIME_TO_STRING

ST    str   (*Result is 'T#12ms' *)

LD    T#300000ms

TIME_TO_DWORD

ST    dw    (*Result is 300000 *)

LD    TOD#00:00:00.012

TOD_TO_SINT

ST    si    (*Result is 12 *)
```

Examples in St:

```
str :=TIME_TO_STRING(T#12ms);          (* Result is
      T#12ms *)

dw:=TIME_TO_DWORD(T#5m);               (* Result is
      300000 *)

si:=TOD_TO_SINT(TOD#00:00:00.012);     (* Result is 12
      *)
```

Examples in FBD:





12.9.6 DATE_TO/DT_TO Conversions

Converting from the variable type DATE or DATE_AND_TIME to a different type:

The date will be stored internally in a DWORD in seconds since Jan. 1, 1970. This value will then be converted.

When you perform a type conversion from a larger to a smaller type, you risk losing some information

For STRING type variables, the result is the date constant.

Examples in St:

```
b :=DATE_TO_BOOL(D#1970-01-01);             (* Result is
      FALSE *)

i :=DATE_TO_INT(D#1970-01-15);              (* Result is
      29952 *)

byt :=DT_TO_BYTE(DT#1970-01-15-05:05:05);   (* Result is
      129 *)

str:=DT_TO_STRING(DT#1998-02-13-14:20);     (* Result is
      'DT#1998-02-13-14:20' *)
```

12.9.7 STRING_TO Conversions

Converting from the variable type STRING to a different type:

The operand from the STRING type variable must contain a value that is valid in the target variable type, otherwise the result will be 0.

Examples in St:

```
b :=STRING_TO_BOOL('TRUE');      (* Result is TRUE *)

w :=STRING_TO_WORD('abc34');     (* Result is 0 *)

t :=STRING_TO_TIME('T#127ms');   (* Result is T#127ms
      *)
```

12.9.8 TRUNC

Converting from REAL to INT. The whole number portion of the value will be used.

When you perform a type conversion from a larger to a smaller type, you risk losing some information.

Examples in ST:

```
i:=TRUNC(1.9);   (* Result is 1 *)

i:=TRUNC(-1.4);  (* result is -1 *).
```

Example in IL:

```
LD    2.7

TRUNC

GE    %MW8
```

12.10 Numeric Functions

12.10.1 ABS

Returns the absolute value of a number. ABS(-2) equals 2.

The following type combinations for input and output variables are possible:

IN	OUT
INT	INT, REAL, WORD, DWORD, DINT
REAL	REAL
BYTE	INT, REAL, BYTE, WORD, DWORD, DINT
WORD	INT, REAL, WORD, DWORD, DINT
DWORD	REAL, DWORD, DINT
SINT	REAL
USINT	REAL
UINT	INT, REAL, WORD, DWORD, DINT, UDINT, UINT
DINT	REAL, DWORD, DINT
UDINT	REAL, DWORD, DINT, UDINT

Example in IL:

```
LD    2

ABS
```

```
ST    i      (*Result is 2 *)
```

Example in ST:

```
i:=ABS(-2);
```

Example in FBD:

12.10.2 SQRT

Returns the square root of a number.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

```
LD    16

SQRT

ST    q      (*Result is 4 *)
```

Example in ST:

```
q:=SQRT(16);
```

Example in FBD:

12.10.3 LN

Returns the natural logarithm of a number.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

```
LD    45

LN

ST    q      (*Result is 3.80666 *)
```

Example in ST:

```
q:=LN(45);
```

Example in FBD:

12.10.4 LOG

Returns the logarithm of a number in base 10.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

```
LD    314.5

LOG

ST    q     (*Result is 2.49762 *)
```

Example in ST:

```
q:=LOG(314.5);
```

Example in FBD:

12.10.5 EXP

Returns the exponential function.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

```
LD    2

EXP

ST    q     (* result is 7.389056099 *)
```

Example in ST:

```
q:=EXP(2);
```

Example in FBD:

12.10.6 SIN

Returns the sine of a number.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

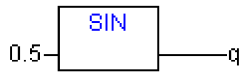
Example in IL:

```
LD    0.5

SIN

ST    q     (*Result is 0.479426 *)
```

Example in ST:

```
q:=SIN(0.5);
```

Example in FBD:



12.10.7 COS

Returns the cosine of number. The value is calculated in arch minutes.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type Typ REAL.

Example in IL:

```
LD    0.5

COS

ST    q     (*Result is 0.877583 *)
```

Example in ST:

```
q:=COS(0.5);
```

Example in FBD:

12.10.8 TAN

Returns the tangent of a number. The value is calculated in arch minutes. IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

```
LD    0.5

TAN

ST    q     (*Result is 0.546302 *)
```

Example in ST:

```
q:=TAN(0.5);
```

Example in FBD:

12.10.9 ASIN

Returns the arc sine (inverse function of sine) of a number. .

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

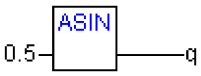
Example in IL:

```
LD    0.5

ASIN

ST    q     (*Result is 0.523599 *)
```

Example in ST:

```
q:=ASIN(0.5);
```

Example in FBD:



12.10.10 ACOS

Returns the arc cosine (inverse function of cosine) of a number. The value is calculated in arch minutes.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

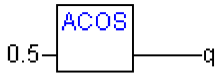
```
LD    0.5
```

```
ACOS

ST    q     (*Result is 1.0472 *)
```

Example in ST:

```
q:=ACOS(0.5);
```

Example in FBD:



12.10.11 ATAN

Returns the arc tangent (inverse function of tangent) of a number. The value is calculated in arch minutes.

IN can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

```
LD    0.5

ATAN

ST    q     (*Result is 0.463648 *)
```

Example in ST:

```
q:=ATAN(0.5);
```

Example in FBD:

12.10.12 EXPT

Exponentiation of a variable with another variable:

```
OUT = IN1IN2.
```

IN1 and IN2 can be type BYTE, WORD, DWORD, INT, DINT, REAL, SINT, USINT, UINT, UDINT, OUT must be type REAL.

Example in IL:

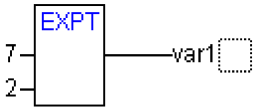
```
LD    7

EXPT  2
```

```
ST    var1  (*Result is 49 *)
```

Example in ST:

```
var1 := EXPT(7,2);
```

Example in FBD:



13 Standard Library Elements

13.1 String functions

Note:
String functions are not "thread safe": When using tasks, string functions may only be used in a single task. If the same function is used in different tasks, there is a danger of overwriting.

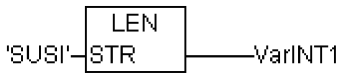
13.1.1 LEN

Returns the length of a string. Input STR is of type STRING, the return value of the function is type INT.

Example in IL:

```
LD    'SUSI'

LEN

ST    VarINT1     (* Ergebnis ist 4 *)
```

Example in FBD:



Example in ST:

```
VarSTRING1 := LEN ('SUSI');
```

Note:
String functions are not "thread safe"

13.1.2 LEFT

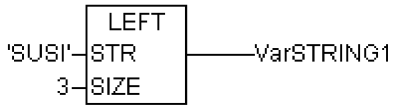
Left returns the left, initial string for a given string. Input STR is type STRING, SIZE is of type INT, the return value of the function is type STRING.

LEFT (STR, SIZE) means: Take the first SIZE character from the right in the string STR.

Example in IL:

```
LD    'SUSI'

LEFT  3

ST    VarSTRING1 (* Ergebnis ist 'SUS' *)
```

Example in FBD:



Example in ST:

```
VarSTRING1 := LEFT ('SUSI',3);
```

Note:
String functions are not "thread safe"!

13.1.3 RIGHT

Right returns the right, initial string for a given string.

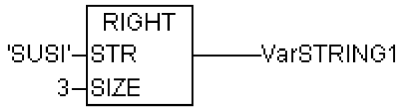
RIGHT (STR, SIZE) means: Take the first SIZE character from the right in the string STR.

Input STR is of type STRING, SIZE is of type INT, the return value of the function is of type STRING.

Example in IL:

```
LD    'SUSI'

RIGHT 3

ST    VarSTRING1 (* Ergebnis ist 'USI' *)
```

Example in FBD:

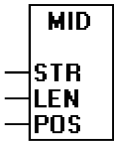


Example in ST:

```
VarSTRING1 := RIGHT ('SUSI',3);
```

Note:
String functions are not "thread safe"!

13.1.4 MID



Mid returns a partial string from within a string.

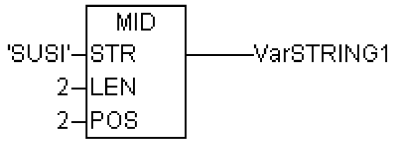
Input STR is type STRING, LEN and POS are type INT, the return value of the function is type STRING.

MID (STR, LEN, POS) means: Retrieve LEN characters from the STR string beginning with the character at position POS.

Example in IL:

```
LD    'SUSI'

RIGHT 2,2

ST    VarSTRING1 (* Ergebnis ist 'US' *)
```

Example in FBD:



Example in ST:

```
VarSTRING1 := MID ('SUSI',2,2);
```

Note:
String functions are not "thread safe"!

13.1.5 CONCAT

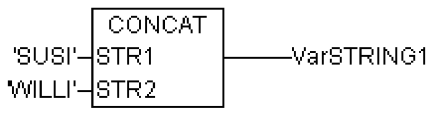
Concatenation (combination) of two strings.

The input variables STR1 and STR2 as well as the return value of the function are type STRING.

Example in IL:

```
LD    'SUSI'

CONCAT      'WILLI'

ST    VarSTRING1 (* Ergebnis ist 'SUSIWILLI' *)
```

Example in FBD:



Example in ST:

```
VarSTRING1 := CONCAT ('SUSI','WILLI');
```

Note:
String functions are not "thread safe"!

13.1.6 INSERT

INSERT inserts a string into another string at a defined point.

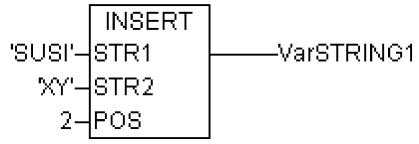
The input variables STR1 and STR2 are type STRING, POS is type INT and the return value of the function is type STRING.

INSERT(STR1, STR2, POS) means: insert STR2 into STR1 after position POS.

Example in IL:

```
LD    'SUSI'

INSERT      'XY',2

ST    VarSTRING1 (* Ergebnis ist 'SUXYSI' *)
```

Example in FBD:



Example in ST:

```
VarSTRING1 := INSERT ('SUSI','XY',2);
```

Note:
String functions are not "thread safe"!

13.1.7 DELETE

DELETE removes a partial string from a larger string at a defined position.

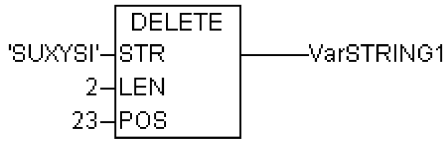
The input variable STR is type STRING, LEN and POS are type INT, the return value of the function is type STRING.

DELETE(STR, L, P) means: Delete L characters from STR beginning with the character in the P position.

Example in IL:

```
LD    'SUXYSI'

DELETE      2,23

ST    Var1  (* Ergebnis ist 'SUSI' *)
```

Example in FBD:



Example in ST:

```
Var1 := DELETE ('SUXYSI',2,3);
```

Note:
String functions are not "thread safe"!

13.1.8 REPLACE

REPLACE replaces a partial string from a larger string with a third string.

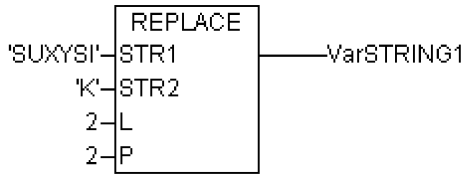
The input variable STR1 and STR2 are type STRING, LEN and POS are type INT, the return value of the function is type STRING.

REPLACE(STR1, STR2, L, P) means: Replace L characters from STR1 with STR2 beginning with the character in the P position.

Example in IL:

```
LD    'SUXYSI'

REPLACE     'K',2,2

ST    VarSTRING1 (* Ergebnis ist 'SKYSI' *)
```

Example in FBD:



Example in ST:

```
VarSTRING1 := REPLACE ('SUXYSI','K',2,2);
```

Note:
String functions are not "thread safe"!

13.1.9 FIND

FIND searches for a partial string within a string.

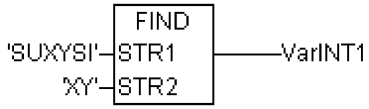
The input variable STR1 and STR2 are type STRING, the return value of the function is type STRING.

FIND(STR1, STR2) means: Find the position of the first character where STR2 appears in STR1 for the first time. If STR2 is not found in STR1, then OUT:=0.

Example in IL:

```
LD    'SUXYSI'

FIND  'XY'

ST    VarINT1     (* Ergebnis ist '3' *)
```

Example in FBD:



Example in ST:

```
arINT1 := FIND ('SUXYSI','XY');
```

Note:
String functions are not "thread safe"!

13.2 Bistable Function Blocks

13.2.1 SR

Making Bistable Function Blocks Dominant:

Q1 = SR (SET1, RESET) means:

```
Q1 = (NOT RESET AND Q1) OR SET1
```

The input variables SET1 and RESET as well as the output variable Q1 are type BOOL.

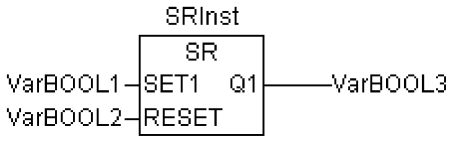
Declaration example:

```
SRInst : SR ;
```

Example in IL:

```
CAL   SRInst(SET1 := VarBOOL1, RESET := VarBOOL2)

LD    SRInst.Q1

ST    VarBOOL3
```

Example in FBD:



Example in ST:

```
SRInst(SET1:= VarBOOL1 , RESET:=VarBOOL2 );

VarBOOL3 := SRInst.Q1 ;
```

13.2.2 RS

Resetting Bistable Function Blocks

Q1 = RS (SET, RESET1) means:

```
Q1 = NOT RESET1 AND (Q1 OR SET)
```

The input variables SET and RESET1 as well as the output variable Q1 are type BOOL.

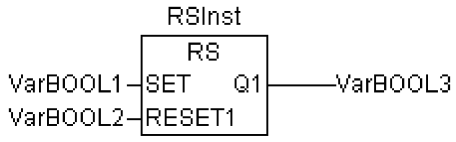
Declaration example:

```
RSInst : RS ;
```

Example in IL:

```
CAL   RSInst(SET := VarBOOL1, RESET1 := VarBOOL2)

LD    RSInst.Q1

ST    VarBOOL3
```

Example in FBD:



Example in ST:

```
RSInst(SET:= VarBOOL1 , RESET1:=VarBOOL2 );

VarBOOL3 := RSInst.Q1 ;
```

13.2.3 SEMA

A Software Semaphore (Interruptible)

BUSY = SEMA(CLAIM, RELEASE) means:

```
BUSY := X;

IF CLAIM THEN X:=TRUE;

ELSE IF RELEASE THEN BUSY := FALSE; X:= FALSE;

END_IF
```

X is an internal BOOL variable that is FALSE when it is initialized.
The input variables CLAIM and RELEASE as well as the output variable BUSY are type BOOL.

If BUSY is TRUE when SEMA is called up, this means that a value has already been assigned to SEMA (SEMA was called up with CLAIM = TRUE). If BUSY is FALSE, SEMA has not yet been called up or it has been released (called up with RELEASE = TRUE).

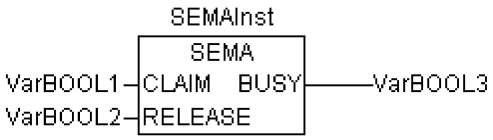
Declaration example:

```
SEMAInst : SEMA ;
```

Example in IL:

```
CAL   SEMAInst(CLAIM := VarBOOL1, RELEASE := VarBOOL2)

LD    SEMAInst.BUSY

ST    VarBOOL3
```

Example in FBD:



Example in ST:

```
SEMAInst(CLAIM:= VarBOOL1 , RELEASE:=VarBOOL2 );

VarBOOL3 := SEMAInst.BUSY;
```

13.3 Trigger

13.3.1 R_TRIG

The function block R_TRIG detects a rising edge.

```
FUNCTION_BLOCK R_TRIG

VAR_INPUT
```

```
      CLK : BOOL;
END_VAR
VAR_OUTPUT
      Q : BOOL;
END_VAR
VAR
      M : BOOL := FALSE;
END_VAR
      Q0 := CLK AND NOT M;
      M := CLK;
END_FUNCTION_BLOCK
```

The output Q0 and the help variable M will remain FALSE as long as the input variable CLK is FALSE. As soon as S1 returns TRUE, Q will first return TRUE, then M will be set to TRUE. This means each time the function is called up, Q will return FALSE until CLK has falling edge followed by an rising edge.

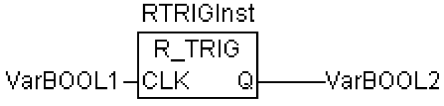
Declaration example:

```
RTRIGInst : R_TRIG ;
```

Example in IL:

```
CAL   RTRIGInst(CLK := VarBOOL1)
LD    RTRIGInst.Q
ST    VarBOOL2
```

Example in FBD:



Example in ST:

```
RTRIGInst(CLK:= VarBOOL1);
VarBOOL2 := RTRIGInst.Q;
```

13.3.2 F_TRIG

The function block F_TRIG a falling edge.

```
FUNCTION_BLOCK F_TRIG

VAR_INPUT

      CLK: BOOL;

END_VAR

VAR_OUTPUT

      Q: BOOL;

END_VAR

VAR

      M: BOOL := FALSE;

END_VAR

      Q := NOT CLK AND NOT M;

      M := NOT CLK;

END_FUNCTION_BLOCK
```

The output Q and the help variable M will remain FALSE as long as the input variable CLK returns TRUE. As soon as CLK returns FALSE, Q will first return TRUE, then M will be set to TRUE. This means each time the function is called up, Q will return FALSE until CLK has a rising followed by a falling edge.

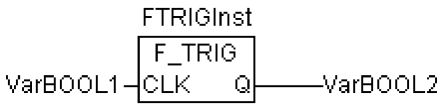
Declaration example:

```
FTRIGInst : F_TRIG ;
```

Example in IL:

```
CAL   FTRIGInst(CLK := VarBOOL1)

LD    FTRIGInst.Q

ST    VarBOOL2
```

Example in FBD:



Example in ST:

```
FTRIGInst(CLK:= VarBOOL1);

VarBOOL2 := FTRIGInst.Q;
```

13.4 Counter

13.4.1 CTU

The function block Incrementer:

The input variables CU and RESET as well as the output variable Q are type BOOL, the input variable PV and the output variable CV are type INT.

The counter variable CV will be initialized with 0 if RESET is TRUE. If CU has a rising edge from FALSE to TRUE, CV will be raised by 1.Q will return TRUE when CV is greater than or equal to the upper limit PV.

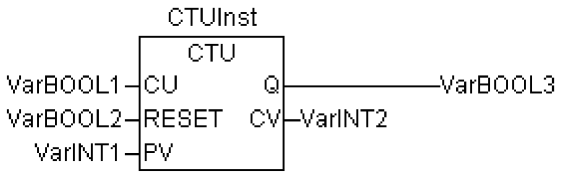
Declaration example:

```
CTUInst : CTU ;
```

Example in IL:

```
CAL   CTUInst(CU := VarBOOL1, RESET := VarBOOL2, PV :=
      VarINT1)

LD    CTUInst.Q

ST    VarBOOL3

LD    CTUInst.CV

ST    VarINT2
```

Example in FBD:



Example in ST:

```
CTUInst(CU:= VarBOOL1, RESET:=VarBOOL2 , PV:= VarINT1);

VarBOOL3 := CTUInst.Q ;

VarINT2 := CTUInst.CV;
```

13.4.2 CTD

Function Block Decrementer:

The input variables CD and LOAD as well as the output variable Q are type BOOL, the input variable PV and the output variable CV are type INT.

When LOAD_ is TRUE, the counter variable CV will be initialized with the upper limit PV. If CD has a rising edge from FALSE to TRUE, CV will be lowered by 1 provided CV is greater than 0 (i.e., it doesn't cause the value to fall below 0).

Q returns TRUE when CVis equal 0.

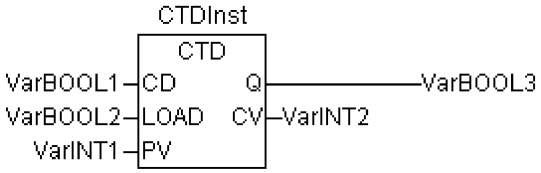
Declaration example:

```
CTDInst : CTD ;
```

Example in IL:

```
CAL   CTDInst(CD := VarBOOL1, LOAD := VarBOOL2, PV :=
      VarINT1)

LD    CTDInst.Q

ST    VarBOOL3

LD    CTDInst.CV

ST    VarINT2
```

Example in FBD:



Example in ST:

```
CTDInst(CD:= VarBOOL1, LOAD:=VarBOOL2 , PV:= VarINT1);

VarBOOL3 := CTDInst.Q ;

VarINT2 := CTDInst.CV;
```

13.4.3 CTUD

Function Block Incrementer/Decrementer:

The input variables CU, CD, RESET, LOAD as well as the output variables QU and QD are type BOOL, PV and CV are type INT.

If RESET is valid, the counter variable CV will be initialized with 0. If LOAD is valid, CV will be initialized with PV.

If CU has a rising edge from FALSE to TRUE, CV will be raised by 1. If CD has a rising edge from FALSE to TRUE, CV will be lowered by 1 provided this does not cause the value to fall below 0.

QU returns TRUE when CV has become greater than or equal to PV.

QD returns TRUE when CV has become equal to 0.

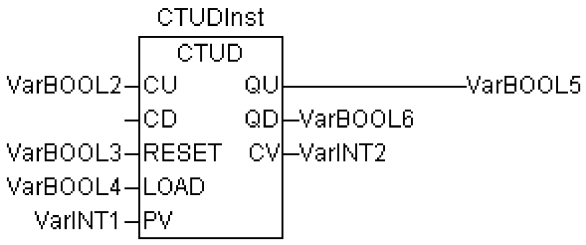
Declaration example:

```
CTUDInst : CUTD ;
```

Example in IL:

```
CAL   CTUDInst(CU := VarBOOL2, RESET := VarBOOL3, LOAD
      := VarBOOL4, PV := VarINT1)

LD    CTUDInst.QU

ST    VarBOOL5

LD    CTUDInst.QD

ST    VarBOOL6

LD    CTUDInst.CV

ST    VarINT2
```

Example in FBD:



Example in ST:

```
CTUDInst(CU := VarBOOL1, CU:= VarBOOL2, RESET :=
      VarBOOL3, LOAD:=VarBOOL4 , PV:= VarINT1);

VarBOOL5 := CTUDInst.QU ;

VarBOOL6 := CTUDInst.QD ;

VarINT2 := CTUDInst.CV;
```

13.5 Timer

13.5.1 TP

The function block TP is a trigger. TP(IN, PT, Q, ET) means:

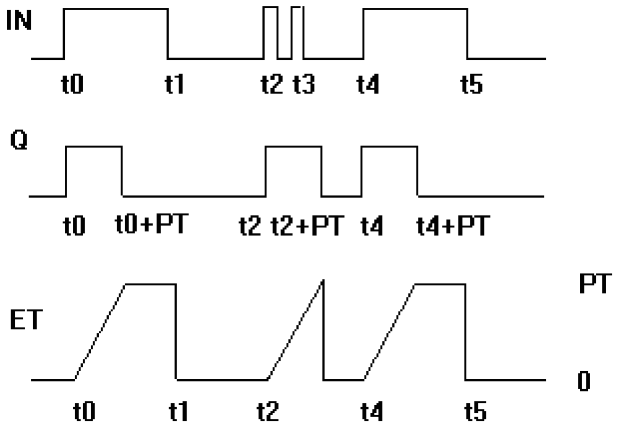
IN and PT are input variables of the BOOL and TIME types respectively. Q and ET are output variables of the BOOL and TIME types respectively. If IN is FALSE, Q is FALSE and ET is 0.

As soon as IN becomes TRUE, the time will begin to be counted in milliseconds in ET until its value is equal to PT. It will then remain constant.

Q is TRUE if IN is TRUE and ET is less than or equal to PT. Otherwise it is FALSE.

Q returns a signal for the time period given in PT.

Graphic Display of the TP Time Sequence



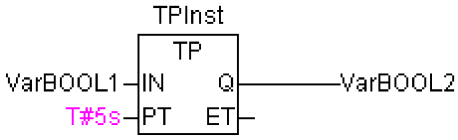
Declaration example:

```
TPInst : TP ;
```

Example in IL:

```
CAL   TPInst(IN := VarBOOL1, PT := T#5s)

LD    TPInst.Q

ST    VarBOOL2
```

Example in FBD:



Example in ST:

```
TPInst(IN := VarBOOL1, PT:= T#5s);

VarBOOL2 :=TPInst.Q;
```

13.5.2 TON

The function block TOD implements a turn-on delay..

TON(IN, PT, Q, ET) means:

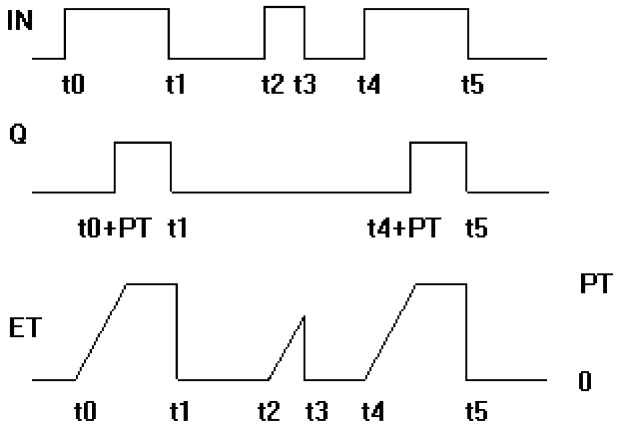
IN and PT are input variables of the BOOL and TIME types respectively. Q and ET are output variables of the BOOL and TIME types respectively. If IN is FALSE, Q is FALSE and ET is 0.

As soon as IN becomes TRUE, the time will begin to be counted in milliseconds in ET until its value is equal to PT. It will then remain constant.

Q is TRUE when IN is TRUE and ET is equal to PT. Otherwise it is FALSE.

Thus, Q has a rising edge when the time indicated in PT in milliseconds has run out.

Graphic display of TON behavior over time:



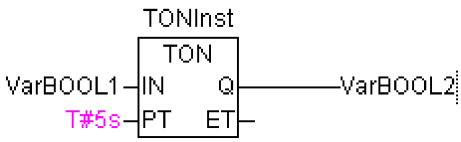
Declaration example:

```
TONInst : TON ;
```

Example in IL:

```
CAL   TONInst(IN := VarBOOL1, PT := T#5s)

LD    TONInst.Q

ST    VarBOOL2
```

Example in FBD:



Example in ST:

```
TONInst(IN := VarBOOL1, PT:= T#5s);
```

13.5.3 TOF

The function block TOF implements a turn-off delay..

TOF(IN, PT, Q, ET) means:

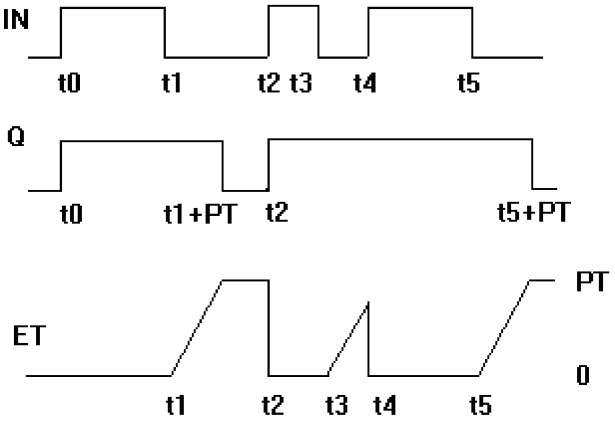
IN and PT are input variables type BOOL respectively TIME. Q and E are output variabls type BOOL respectively TIME. If IN is TRUE, the outputs are TRU respectively 0.

As soon as IN becomes FALSE, in ET the time will begin to be counted in milliseconds in ET until its value is equal to PT. It will then remain constant.

Q is FALSE when IN is FALSE und ET equal PT. Otherwise it is TRUE.

Thus, Q has a falling edge when the time indicated in PT in milliseconds has run out.

Graphic display of TOF behavior over time:



Declaration example:

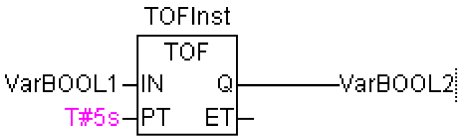
```
TOFInst : TOF ;
```

Example in IL:

```
CAL   TOFInst(IN := VarBOOL1, PT := T#5s)

LD    TOFInst.Q
```

```
ST    VarBOOL2
```

Example in FBD:



Example in ST:

```
TOFInst(IN := VarBOOL1, PT:= T#5s);

VarBOOL2 :=TOFInst.Q;
```

14 The UTIL.LIB Library

14.1 UTIL.LIB Library

This library contains an additional collection of various blocks which can be used for BCD conversion, bit/byte functions, mathematical help functions, as controller, signal generators, function manipulators and for analogue value processing.

14.2 BCD conversion

A byte in the BCD format contains integers between 0 and 99. Four bits are used for each decimal place. The ten decimal place is stored in the bits 4-7. Thus the BCD format is similar to the hexadecimal presentation, with the simple difference that only values between 0 and 99 can be stored in a BCD byte, whereas a hexadecimal byte reaches from 0 to FF.

An example: The integer 51 should be converted to BCD format. 5 in binary is 0101, 1 in binary is 0001, which makes the BCD byte 01010001, which corresponds to the value $51=81.

14.2.1 BCD_TO_INT

This function converts a byte in BCD format into an INT value:

The input value of the function is type BYTE and the output is type INT.

Where a byte should be converted which is not in the BCD format the output is -1.

Examples in ST:

```
i:=BCD_TO_INT(73);    (* Result is 49 *)

k:=BCD_TO_INT(151);   (* Result is 97 *)

l:=BCD_TO_INT(15);    (* Output -1, because it is not
     in BCD format *)
```

14.2.2 INT_TO_BCD_

This function converts an INTEGER value into a byte in BCD format:

The input value of the function is type INT, the output is type BYTE.

The number 255 will be outputted where an INTEGER value should be converted which cannot be converted into a BCD byte.

Examples in ST:

```
i:=INT_TO_BCD(49);    (* Result is 73 *)
```

```
k:=BCD_TO_INT(97);     (* Result is 151 *)

l:=BCD_TO_INT(100);    (* Error! Output: 255 *)
```

14.3 Bit/byte functions

14.3.1 EXTRACT

Inputs to this function are a DWORD X, as well as a BYTE N. The output is a BOOL value, which contains the content of the N^{th} bit of the input X, whereby the function begins to count from the zero bit.

Examples in ST:

```
FLAG:=EXTRACT(X:=81, N:=4);(* Result : TRUE, because 81
     is binary 1010001, so the 4th bit is 1 *)

FLAG:=EXTRACT(X:=33, N:=0);(* Result : TRUE, because 33
     is binary 100001, so the bit '0' is 1 *)
```

14.3.2 PACK

This function is capable of delivering back eight input bits B0, B1, ..., B7 from type BOOL as a BYTE.

The function block UNPACK is closely related to this function.

14.3.3 PUTBIT

The input to this function consists of a DWORD X, a BYTE N and a BOOLean value B.

PUTBIT sets the N^{th} bit from X on the value B, whereby it starts counting from the zero bit.

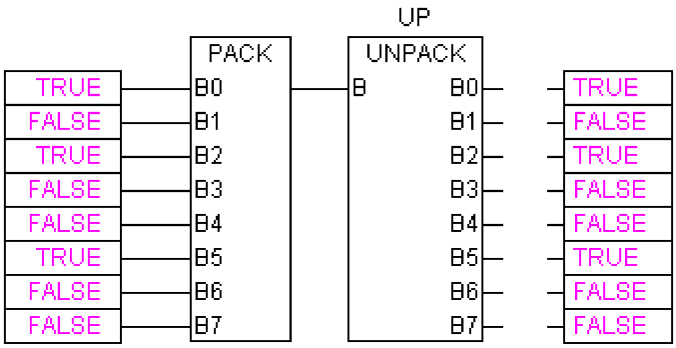
Example in ST:

```
A:=38;                 (* binary 100110 *)

B:=PUTBIT(A,4,TRUE);   (* Result : 54 = 2#110110 *)

C:=PUTBIT(A,1,FALSE); (* Result : 36 = 2#100100 *)
```

14.3.4 UNPACK

UNPACK converts the input B from type BYTE into 8 output variables B0,...,B7 of the type BOOL, and this is the opposite to PACK.

Example in FBD:



14.4 Mathematical help functions

14.4.1 DERIVATIVE

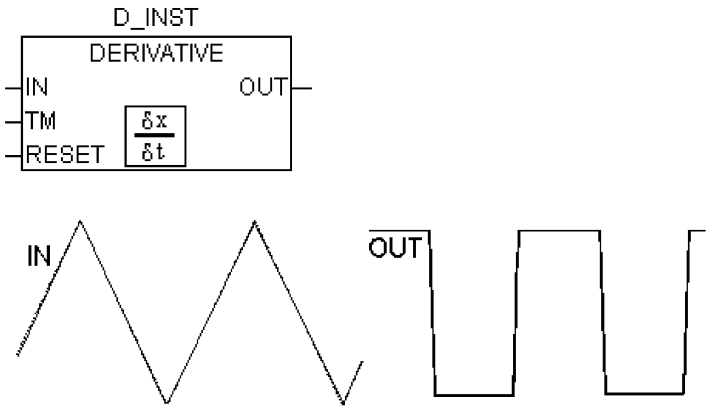
This function block approximately determines the local derivation.

The function value is delivered as a REAL variable by using IN. TM contains the time which has passed in msec in a DWORD and the input of RESET of the type BOOL allows the function block to start anew through the delivery of the value TRUE.

The output OUT is of the type REAL.

In order to obtain the best possible result, DERIVATIVE approximates using the last four values, in order to hold errors which are produced by inaccuracies in the input parameters as low as possible.

Block in FBD:



14.4.2 INTEGRAL

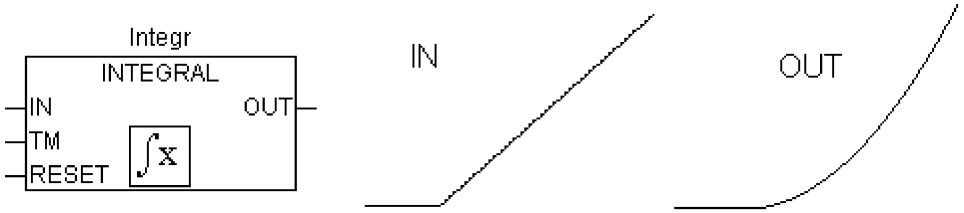
This function block approximately determines the integral of the function.

In an analogue fashion to DERIVATIVE, the function value is delivered as a REAL variable by using IN. TM contains the time which has passed in msec in a DWORD and the input of RESET of the type BOOL allows the function block to start anew with the value TRUE.

The output OUT is of the type REAL.

The integral is approximated by two step functions. The average of these is delivered as the approximated integral.

Block in FBD: Example: Integration of a linear function:



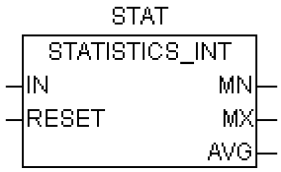
14.4.3 STATISTICS_INT

This function block calculates some standard statistical values:

The input IN is of the type INT. All values are initialised anew when the BOOLean input RESET is TRUE.

The output MN contains the minimum, MX of the maximum value from IN. AVG describes the average, that is the expected value of IN. All three outputs are of the type INT.

Block in FBD:



14.4.4 STATISTICS_REAL

This function block corresponds to STATISTICS_INT, except that the input IN is of the type REAL like the outputs MN, MX, AVG.

14.4.5 VARIANCE

VARIANCE calculates the variance of the entered values.

The input IN is of the type REAL, RESET is of the type BOOL and the output OUT is again of the type REAL.

This block calculates the variance of the inputted values. VARIANCE can be reset with RESET=TRUE.

The standard deviation can easily be calculated as the square root of the VARIANCE.

14.5 Controllers

14.5.1 P

The P controller function block:

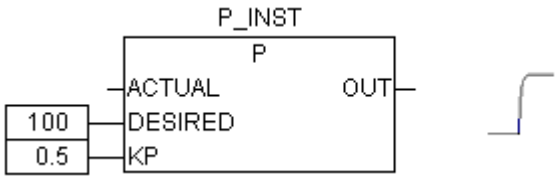
ACTUAL (actual value) and DESIRED (desired or nominal value) as well as KP, the proportionality coefficient, are all input values of the type REAL.

The output, the absolute control output (OUT), is of the type REAL, and is calculated as follows:

$$OUT = ACTUAL + KP \cdot \Delta ,$$

whereby Δ=DESIRED-ACTUAL.

Example in FBD:



14.5.2 PD

The PD controller function block:

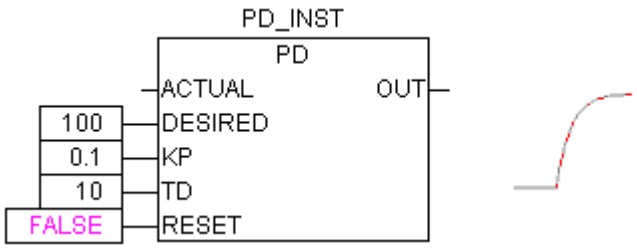
ACTUAL (actual value) and DESIRED (desired or nominal value) as well as KP, the proportionality coefficient, are all input values of the type REAL. TD is of the type DWORD and contains the derivative action time in msec. RESET is of the type BOOL and serves to reset the controller.

The output, the absolute control output (OUT), is of the type REAL, and is calculated as follows:

$$OUT = ACTUAL + KP \cdot \left(\Delta + TD \cdot \frac{\delta \Delta}{\delta t} \right) ,$$

whereby Δ=DESIRED-ACTUAL.

Example in FBD:



14.5.3 PID

The PID controller function block:

ACTUAL (actual value) and DESIRED (desired or nominal value) as well as KP, the proportionality coefficient, are all input values of the type REAL. TR, the integral action time, and TD, the derivative action time, are delivered in msec by a DWORD. RESET is of the type BOOL and serves to reset the controller.

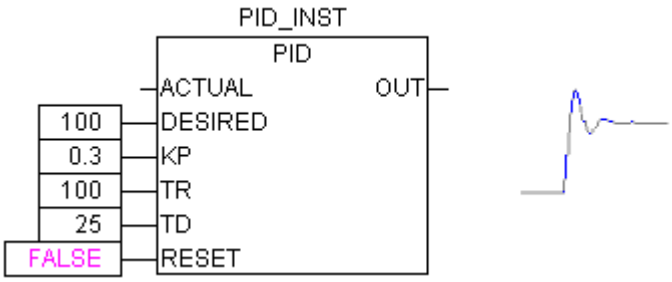
The output, the absolute control output (OUT), is of the type REAL, and is calculated as follows:

$$OUT = ACTUAL + KP \cdot \left(\Delta + \frac{1}{TR} \int \Delta(t)dt + TD \cdot \frac{\delta\Delta}{\delta t} \right),$$

whereby Δ=DESIRED-ACTUAL.

The PID controller can be easily converted to a PI controller by setting TD=0.

Example in FBD:



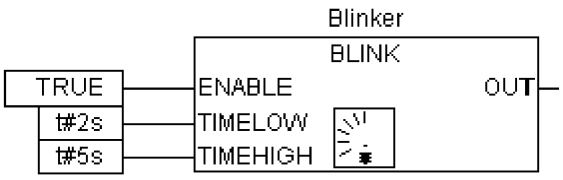
14.6 Signal generators

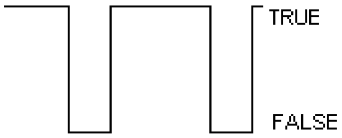
14.6.1 BLINK

The function block BLINK generates a pulsating signal. The input consists of ENABLE of the type BOOL, as well as TIMELOW and TIMEHIGH of the type TIME. The output OUT is of the type BOOL.

If ENABLE is set to TRUE, BLINK begins, to set the output for the time period TIMEHIGH to TRUE, and then afterwards to set it for the time period TIMELOW to FALSE.

Example in CFC:





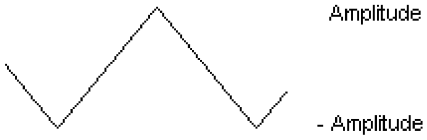
14.6.2 GEN

The function generator generates typical periodic functions:

The inputs are a composition consisting of MODE from the pre-defined counting type GEN_MODE, BASE of the type BOOL, PERIOD of the type TIME, of two INT values CYCLES and AMPLITUDE and of the BOOLean RESET input.

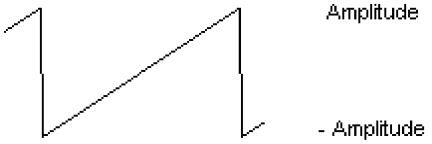
The MODE describes the function which should be generated, whereby the enumeration values TRIANGLE and TRIANGLE_POS deliver two triangular functions, SAWTOOTH_RISE an ascending, SAWTOOTH_FALL a descending sawtooth, RECTANGLE a rectangular signal and SINE and COSINE the sine and cosine:

TRIANGLE:

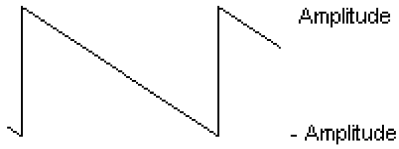


TRIANGLE_POS:

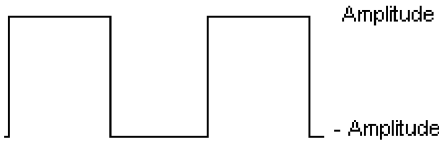
SAWTOOTH_RISE:



SAWTOOTH_FALL:



RECTANGLE:



SINUS:

COSINUS:

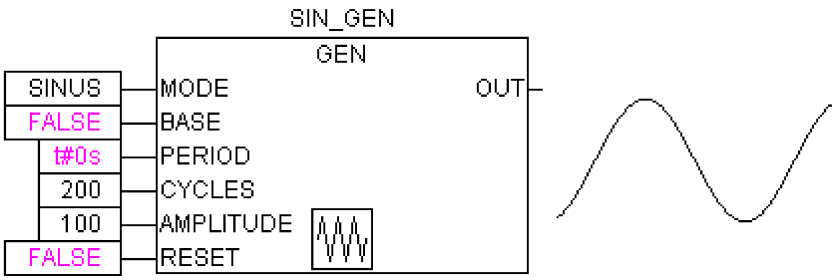
BASE defines whether the cycle period is really related to a defined time (BASE=TRUE) or whether it is related to a particular number of cycles, which means the number of calls of function block (BASE=FALSE).

PERIOD or CYCLES defines the corresponding cycle period.

AMPLITUDE defines, in a trivial way, the amplitude of the function to be generated.

The function generator is again set to 0 as soon as RESET=TRUE.

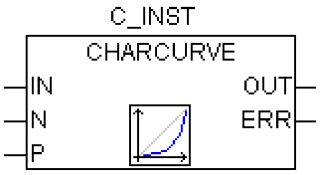
Example in FBD:



14.7 Function manipulators

14.7.1 CHARCURVE

This function block serves to represent values, piece by piece, on a linear function:



IN of the type INT is fed with the value to be manipulated. The BYTE N designates the number of points which defines the presentation function. This characteristic line is then generated in an ARRAY P[0..10] with P of the type POINT which is a structure based on two INT values (X and Y).

The output consists of OUT of the type INT, the manipulated value and BYTE ERR, which will indicate an error if necessary.

The points P[0]..P[N-1] in the ARRAY must be sorted according to their X values, otherwise ERR receives the value 1. If the input IN is not between P[0].X and P[N-1].X, ERR=2 and OUT contains the corresponding limiting value P[0]. Y or P[N-1].Y.

If N lies outside of the allowed values which are between 2 and 11, then ERR=4.

Example in ST:

First of all ARRAY P must be defined in the header:

```
VAR
```

```
        ...

        CHARACTERISTIC_LINE:CHARCURVE;

        KL:ARRAY[0..10] OF POINT:= (X:=0,Y:=0),
        (X:=250,Y:=50), (X:=500,Y:=150), (X:=750,Y:=400),
        7((X:=1000,Y:=1000));

        COUNTER:INT;

        ...

END_VAR
```

Then we supply CHARCURVE with for example a constantly increasing value:

```
COUNTER:=COUNTER+10;

      CHARACTERISTIC_LINE(IN:=COUNTER,N:=5,P:=KL);
```

The subsequent tracing illustrates the effect:

14.7.2 RAMP_INT

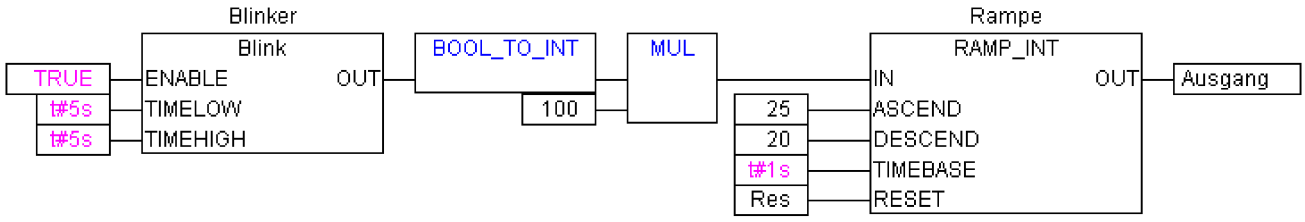
RAMP_INT serves to limit the ascendance or descendance of the function being fed:

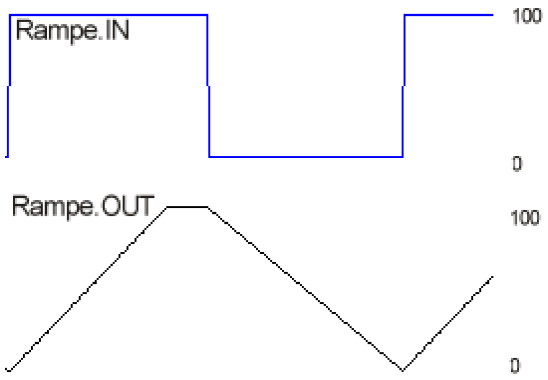
The input consists on the one hand out of three INT values: IN, the function input, and ASCEND and DESCEND, the maximum increase or decrease for a given time interval, which is defined by TIMEBASE of the type TIME. Setting RESET to TRUE causes RAMP_INT to be initialised anew.

The output OUT of the type INT contains the ascend and descend limited function value.

When TIMEBASE is set to t#0s, ASCEND and DESCEND are not related to the time interval, but remain the same.

Example in CFC:





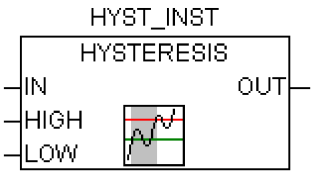
14.7.3 RAMP_REAL

RAMP_REAL functions in the same way as RAMP_INT, with the simple difference that the inputs IN, ASCEND, DESCEND and the output OUT are of the type REAL.

14.8 Analogue value processing

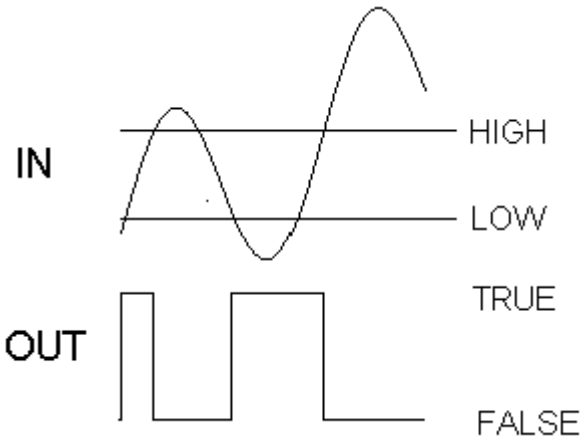
14.8.1 HYSTERESIS

The input to this function block consists of three INT values IN, HIGH and LOW. The output OUT is of the type BOOL.



If IN goes below the limiting value LOW, OUT becomes TRUE. If IN goes over the upper limit HIGH, FALSE is delivered.

An illustrative example:



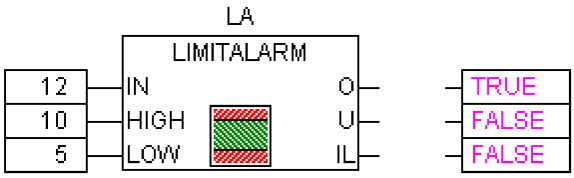
14.8.2 LIMITALARM

This function block specifies, whether the input value is within a set range and which limits it has violated if it has done so.

The input values IN, HIGH and LOW are each of the type INT, while the outputs O, U and IL are of the type BOOL.

If the upper limit HIGH is exceeded by IN, O becomes TRUE, and when IN is below LOW, U becomes TRUE. IL is TRUE if IN lies between LOW and HIGH.

Example in FBD:



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